Oregon State University OSU Coastal Oregon Marine Experiment Station

June 18, 2015

Hugh Link, Executive Director
Oregon Dungeness Crab Commission
P.O. Box 1160
Coos Bay, OR 67420

Subject: Proposal to Develop a Bio-Economic Model and Evaluate Economic and Biological Benefits of Alternative Management Strategies for the Oregon Dungeness Crab Commercial Fishery

Dear Mr. Link:

Attached please find a proposal from the Coastal Oregon Marine Experiment Station (COMES) of Oregon State University to undertake the referenced project and address information gaps in the Oregon Dungeness crab fishery. The proposal contents include background discussion and research methods, timeline, budget, and references. We have assembled a strong research team with considerable experience in fishery economics, bio-economic modelling, and fishery and crab biology – including more than fifty years of research on Oregon's fishing and seafood industries. The project lead is Dr. Gil Sylvia, Director of COMES. Other team members include Shannon Davis of The Research Group, LLC, and Noelle Yochum and Chris Cusack, Ph.D. students at OSU.

COMES and OSU will be able to provide in-kind match totaling about $34 thousand to the project with ODCC participation being $80 thousand. Although we believe the budget is commensurate with the amount of work, we are willing to discuss adjustments in the research objectives and budget levels.

If our proposal is accepted, the Agricultural Research Foundation (ARF) will be the project's fiscal agent by holding the prime contract with the ODCC. This will preclude having to reimburse OSU for indirect costs associated with their facility and administrative rate. Also, the ARF does not charge an administrative fee for their services.

We anticipate the project beginning July 1, 2015, and lasting 13 months and ending July 31, 2016.

Hatfield Marine Science Center
2030 Marine Science Drive, Newport, Oregon 97365
Tel: 541-867-0230 Fax: 541-867-0345 http://marineresearch.oregonstate.edu

The proposed project has unique elements that we believe will strengthen its value to the ODCC and management of the Oregon Dungeness crab fishery.

- The bio-economic model is designed so it will be a flexible and useful analytical tool that can be utilized by non-economists including ODCC staff and board members, industry, and fishery management agencies.
- We will assist ODCC establish a steering committee composed of ODCC staff, board members, industry representatives, ODFW staff, and other ODCC funded researchers conducting related projects. The ODCC may want even other agency and technicians on the committee. We have budgeted for three meetings during the course of the project to get their input and ideas and make sure the model meets expectations for being able to evaluate alternative management strategies.
- The model and analysis will incorporate results from other studies, including research on bycatch and cannibalism. We anticipate generating ideas and methods that could strengthen proposed or ongoing studies.
- We will conduct a final workshop with ODCC that presents the findings, generates alternative ideas for research and management, and instructs workshop participants on using the interactive model.

Thank you for the opportunity to provide the enclosed proposal. We look forward to working with the ODCC on this important project and are available to make a personal presentation to explain our proposal. Please do not hesitate to contact me if you have any questions.

Sincerely,

Gil Sylvia
Marine Resource Economist
Director, Coastal Oregon Marine Experiment Station

Summary
Oregon Dungeness Crab Commission
Research Proposal

1. Title.

Develop a Bio-Economic Model and Evaluate Economic and Biological Benefits of Alternative Management Strategies for the Oregon Dungeness Crab Commercial Fishery

2. Principal investigator(s) and contact information.

Gil Sylvia[1], Shannon Davis[2], Noëlle Yochum[3], Christopher Cusack[4]
1. Director, Coastal Oregon Marine Experiment Station; Professor, Oregon State University
2. Principal, The Research Group, LLC
3. PhD Candidate, Department of Fisheries and Wildlife, Oregon State University
4. PhD Candidate, Department of Applied Economics, Oregon State University

Contact Information:

Gil Sylvia
Hatfield Marine Science Center
2030 SE Marine Science Drive
Newport, OR 97365
Phone: (541) 867-0284
Email: gil.sylvia@oregonstate.edu

Shannon Davis
The Research Group, LLC
PO Box 813
Corvallis, Oregon 97339-0813
Phone: (541) 758-1432
Email: shannond@trgsystems.net

Noëlle Yochum
Phone: (916) 719-5920
Email: noelle.yochum@oregonstate.edu

Christopher Cusack
Phone: (541) 207-5671
Email: chrisinju@gmail.com

3. Cooperator(s), if any.

None.

4. Outline of research methods.

Research Methods

An interactive bio-economic model will be developed using existing data and research on stock status, fishery prosecution, and harvest mortality effects. **A priority in development and use of the model will be investigating the effects on harvest-related male mortality and cannibalism with respect to stock status and economic impacts on the fishery**. The simulation model will have the flexibility for changing driver inputs when new research information becomes available. An uncertainty analysis will be completed showing how data measurement and other assumptions generate output ranges. The simulation

model will have features to find industry production efficiency results for anticipated and warranted changes to management strategies. A steering committee approach will be used for the development, testing, and utilization of the bio-economic model. A final study deliverable will be functional and documented software for use by ODCC and other researchers.

An outline of the project is as follows:

- Collect best science data and results from economic and biological research papers, fish ticket system, and fishery logbook program.
- Develop simulation model.
    - Three modules: biological, fleet, and economic.
    - Bi-weekly progression and 10 year horizon.
    - Variables include: price, bycatch rates, discard mortality rates, natural mortality, effort (pot soak days), pot loss/ghost fishing mortality, CPUE by depth, landings, average crab size, cannibalism in pots, others.
    - Six plus longitudinal and latitudinal spatial blocks.
    - Output metrics for changes in mortality, catch, industry profitability, community impacts that includes the multiplier effect, and CPUE. Express output measures in terms of avoided costs and net present value.
    - Provide sensitivity and uncertainty analysis.
    - Build-in expanded capabilities to increase the utility of the model for future research on management policies.
    - Scenario development:
        - Realistic conditions that might cause effort shifts temporally.
            - Shrimp fishery (for example) crashes and fishermen fish later.
            - Crab price increases later in the season, increasing effort later in the season.
        - Handling mortality of soft-shelled crab in the summer vs natural mortality and ghost fishing mortality, etc. with respect to rolling over non-catch mortality until the following season.
        - If season setting prevents holiday season supply, how does fill-in from B.C., tribes, WA and CA affect market demand.
        - Incorporate long term trends in recruitment (7-10 year cycles).
        - Review whether supply changes alter price over the season. Does having fresh, local crab in the summer for tourists play a significant role? What is the importance of "Christmas Crab" and "Chinese New Year Crab."
        - Look at abundance patterns (trough to trough cycles, across 10 years, and within years).
    - Evaluate trade-offs with different variable input for scenarios regarding:
        - Season timing when to open and close the fishery: Derby, opening date (Dec 1, 15, Jan 1, 15, Feb 1, other), close date (August 15, July 1, spring, other), status quo.
        - Management strategies such as bi-monthly effort caps (pots and or vessels), or harvest caps by trip or season, tradable pot quotas, limits on pot soak time, or other management tools.

        - Generate tradeoff curves (such as profitability vs. fishing mortality, vs. economic distribution of benefits across fleets, regions or time).
        - For each scenario, what are the social implications (such as small vs. large boat fleet), community impacts (such as location, importance of fishery to the community), spillover behavior to other fisheries for multi-permit vessels, etc., markets.
- Use steering committee to oversee model design and explore project scenario results for consideration of recommending new management strategies. Anticipate three meetings over 13 month timeline. Attend and provide progress reports at ODCC regular meetings.
- Present results at a general workshop to receive feedback on changed management practices that might be of interest to ODCC for recommendation to ODFW and PSMFC.
- Deliver computer application (Microsoft Excel workbook), operations manual, and final report.

Relevance to ODCC Mission

The Oregon Dungeness Crab Commission's (ODCC) mission is to promote sustainability and increased profit in the commercial Oregon Dungeness crab fishery. In support of this mission, our project would address the ODCC research priority of creating a bio-economic model for the commercial Dungeness crab fishery. Our project would provide information on how the timing and extent of the fishing season impacts the health and profitability of the fishery. It would also explain the differential impact on economic output and the crab population from bycatch, discard mortality, cannibalism, and other fishing and biologically related variables. We aim to contribute to the ODCC's mission by generating quality data that can be used to inform management decisions. We will work closely with the ODCC, ODFW, and additional ODCC supported researchers to ensure that our final product represents the most accurate and current information and to maximize the utility of our model.

5. How your work would meet the objectives stated above.

The objective of this project is to create a bio-economic model for evaluating how to optimize the economic, social, and biological benefits from Oregon's Dungeness crab (*Cancer magister*) commercial fishery. This includes evaluating how the timing of the fishing season affects economic benefits, with particular focus on bycatch and discard mortality rates, cannibalism in pots, variability in price, and variability in annual recruitment. We will work with the ODCC and the ODFW to ensure that the model can be used to address management concerns and to evaluate management strategies for improving the sustainability and profitability of the fishery. In addition to working closely with a steering committee and providing regular updates and a final report, we will produce an interactive model with supporting instructions that can be easily used by non-economists and industry and agency personnel.

6. Timeline for project with anticipated duration of study/anticipated project completion date.

We anticipate the project beginning July 1, 2015, and lasting 13 months and ending July 31, 2016.

7. Estimated cost (itemized by project and indicating the amounts for materials and services, and for travel. Each proposer may need to make arrangements to go to sea if the research requires it.)

Budget Expenditures	ODCC	Inkind	Total
Labor	$73,281	$24,320	$97,602
Travel and per diem	$6,000	$0	$6,000
Materials and service	$719	$0	$719
Other (tuition)	$0	$10,154	$10,154
Total	$80,000	$34,474	$114,475

The project assigned Ph.D. students both have recent at-sea experience. Chris Cusack was a NMFS Observer Program employee for seven years in Alaska. Noelle Yochum has made 70 at-sea trips with Oregon crab harvesters to-date for her mortality research project. If necessary for the conduct of the project, the proposed travel budget is sufficient for several at-sea monitoring trips.

8. Include at least three professional references with contact information for someone who can speak to your successes, working relationships and methods of work.

Professional Reference for Gil Sylvia:
Dr. Sherry L. Larkin
Food & Resource Economics
University of Florida
(352) 294-7676
slarkin@ufl.edu

Professional Reference for Shannon Davis:
Christopher N. Carter, Ph.D.
Natural Resource Economist, ODFW (retired)
(503) 703-3321 mobile
(503) 245-3295 home
cncarter@comcast.net

Professional Reference for Noëlle Yochum:
Dr. Allan Stoner
NOAA Alaska Fisheries Science Center (retired)
(541) 270-8602
allan.stoner@gmail.com

Professional Reference for Chris Cusack:
Susan Hanna, Ph.D.
Professor (retired)
Applied Economics Department
Oregon State University
(541) 754-9367
susan.hanna7@gmail.com

PROPOSAL

DEVELOP A BIO-ECONOMIC MODEL AND EVALUATE ECONOMIC AND BIOLOGICAL BENEFITS OF ALTERNATIVE MANAGEMENT STRATEGIES FOR THE OREGON DUNGENESS CRAB COMMERCIAL FISHERY

prepared for:

Oregon Dungeness Crab Commission
Coos Bay, Oregon

prepared by:

Coastal Oregon Marine Experiment Station
Oregon State University
Newport, Oregon

in cooperation with:

The Research Group, LLC
Corvallis, Oregon

June 18, 2015

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I. INTRODUCTION

Changing how a fishery is managed will have consequences to profitability, social impacts, and the size and distribution of the fish stock. While the commercial Dungeness crab fishery in Oregon is a certified sustainable fishery (MSC 2014), an evaluation of current and alternative harvesting and management strategies could reveal opportunities for improving economic benefits. Specifically, it would be helpful to look at economic and community trade-offs with respect to the timing of the fishery as it relates to soft-shelled crab, fishing mortality (including discarding and pot cannibalism) and its impact on future harvest and social and economic benefits. Our objective is to develop a bio-economic model, use the model to analyze alternative management strategies, and produce important industry and community economic and social impact information.

The West Coast Dungeness crab fishery season openings and closings have developed around the timing of the adult annual molt cycle (Didier 2002). By closing the fishery when the crab have recently molted, fishing impacts to the stock are reduced while they harden and fill-in their shells. This decreases handling mortality and increases the value of the crab (Demory 1985; Yochum et al. in preparation). Despite the closure, the season is typically 8 ½-months long and occurs when some soft-shelled crab are captured. However, the majority of landings take place soon after the season opens. After this point, landings and catch per unit effort (CPUE) decline until the season ends (Didier 2002). Additionally, throughout the season there is variation in fishing mortality rates; price; crab weight; relative effort in other fisheries by crab fishery participants; and, potentially, an indirect increase in fishing mortality vial cannibalism. Evaluating these variables in a bio-economic model allows for the determination of optimal timing of the fishing season to reduce impact on soft-shelled animals so that they can be harvested in subsequent years, while maximizing overall economic gains.

In addition to the timing of the fishery, regulations for the commercial Dungeness crab fishery include protection for and prohibition of taking small male (< 6 ¼ inches) and female crab (ODFW 2015). Despite regulatory action, some sub-legal males and females die as a result of fishing mortality, either from handling, the fishing process (Yochum et al. in preparation), ghost fishing (Antonelis et al. 2011), or cannibalism (MacKay 1942). How these components of fishing mortality in a given year affect landings and economic benefits in subsequent months or years must be evaluated against exploitation and natural mortality rates. Anecdotally, the exploitation rate of recruited male crab in Oregon is assumed to be approximately 0.9 (i.e., 90% of recruited crab are harvested each season). However, estimated rates along the Pacific coast range from 0.51 to 0.92 (Methot and Botsford 1982; Jow 1965; Gotshall 1978a; Smith and Jamieson 1989), and change annually, by area (Methot and Botsford 1982), and with abundance (Jow 1965). Moreover, while not exploited, all non-captured and discarded crab are subject to natural mortality (i.e., mortality from causes other than fishing such as disease, predation, aging, etc.). Natural mortality rates (the proportion of crab dying during a year due to "natural" causes to those alive at the beginning of the year) have been estimated to range from 0.15-0.45, and to vary by size and molt stage (Jow 1965; Gotshall 1978b; Smith and Jamieson 1989). It is unknown how significantly handling mortality affects future recruitment given these high cumulative rates of exploitation and natural mortality, and natural cycles in recruitment (Hankin

1985). Our goal is to help evaluate the possible tradeoffs associated with a range of management strategies and fishing and handling mortality rates using the bio-economic model.

In addition to evaluating ways to understand profitability in the commercial Oregon Dungeness crab fishery, the bio-economic model can be used to consider social aspects of the fishery. Specifically, there are different fishing strategies employed in the fleet. Some vessels primarily land crab for the duration of the season, while others fish in a derby style at the start of the season before switching to an alternative fishery. This quasi-derby style is attributed, in part, to the multi-fishery nature of the fleet. While the strategy used by each permit holder is an individual decision, the price for crab, opportunities in concurrent fisheries, and CPUE, heavily influence when a permit holder exits the Dungeness fishery. These factors contribute to creating an industry "divide" between the larger and smaller boat fleets. In general, there is a tendency for smaller vessels to fish later in the season than larger vessels. These fleet dynamics will be considered in our model along with changes in the structure and patterns of effort. For example, using the model, we will evaluate a variety of scenarios: for example, what happens when there is an increase in effort during the later portion of the fishing season due to a collapse in a concurrent fishery; or, if there is a significant increase in the crab biomass. Our model will demonstrate how changes in the dynamics of the fishery affect overall economic gains and overall fishing mortality.

Currently, the economic, social, and biological parameters that determine fishery outputs vary inter- and intra-annually. Through the development of a bio-economic model, we will evaluate current and alternative management regulations and fishing practices -- within and across years -- with the goal of exploring economic and social benefits and tradeoffs in the commercial Oregon Dungeness crab fishery, while ensuring sustainability of the crab population. This model will also reveal the relative importance of bycatch mortality and pot-cannibalism as components of the overall fishing mortality. Moreover, model sensitivity (i.e., the amount of allowable error around the estimated variables) will be determined for these components of mortality along with other input variables.

II. APPROACH

A. Research Methods

The research methods will center on developing and using a bio-economic model that addresses Objective III.A in the ODCC Request for Proposals (RFP) document. Some of the proposed research, however, has implications for research priorities III.B and III.C that are noted in the sections below.

1. Bio-Economic Model Structure

To conduct the research we will develop an interactive bio-economic computer simulation model using Microsoft Excel software. The model will be capable of providing analysis for the key questions and considerations that the ODCC would like analyzed. The model, including model inputs (parameters, variables, equations) and outputs (e.g., tables, graphs, trade-off curves) will

be designed so that they are defined, accessible to any user (via an "unlock" tool that minimizes unintended changes/mistakes), and transparent (data source, citation, and/or justification). The goal will be to develop a model that can not only be used by the project research team, but easily utilized by the staff and board members of the ODCC and other individuals or organizations that the ODCC chooses to allow access (e.g., members of the Dungeness crab industry and ODFW staff). All data employed within the model or discussed in the final report will be reviewed by ODFW staff and ODCC management to ensure that the data and information do not violate the privacy of any individual or firm participating in the harvesting, processing, or marketing of Dungeness crab.

The bio-economic model will include the following design elements and components:

A ten year bimonthly multi-fleet spatial model structure -- The model will have the capability of being run up to a ten year time period consistent with the needs and objectives of the user. The model will be structured to generate economic and biological outputs on a two week basis (26 two week periods per year beginning December 1) so that annual and in-season fishery questions of interest can be analyzed. Key model outputs (described below) will be summarized in annual tables and graphs for each year as well as over the time horizon selected for analysis. Depending on analysis of the data including logbooks and discussions with the steering committee, the model will employ two (e.g., less or greater than 25 fathoms) or three (less than 10, 10 to 25, more than 25 fathoms) harvest areas, and three spatial harvesting regions (north, central, and south Coast corresponding with management regulated latitudinal delineations). Depending on the availability and quality of the logbook data, we may also be able to evaluate impacts to specific coastal ports of interest to the ODCC. The modeling will account for the adjacent states area-of-catch harvests delivered to Oregon and Oregon fleet deliveries to ports in the adjacent states.

Most parameters in the model will be adjustable to incorporate new and better estimates (including improved estimates for discard mortality and cannibalism developed from research addressing RFP objectives III.B and III.C) and to test "sensitivity" effects of higher or lower values on model outputs (e.g., the effect of higher costs or output prices, higher initial pre-recruit levels, higher bycatch mortality, etc.).

Model modules -- Input model data and structural relationships will be represented within three modules:

1) *Biological Module*: The biological components of the model will be represented by an age-class cohort sub-model that will track – across every two weeks and years – total biomass, growth, natural mortality, fishing mortality by source (includes harvest of recruited males; handling mortality to pre-recruits, adult females, molted crabs of all ages and sexes; and estimates of pot-cannibalism),[1] recruitment (including natural, cyclic

1. Fishing mortality is represented by mathematical equations in the model: for example $TM_{a,g,t,f,r} = NM_{a,g,t,f,r} + FM_{a,g,t,f,r}$ where FM=HMNM +HMM + CM. TM is Total Mortality, NM is natural mortality, FM is fishing mortality, HMNM is handling non-molting fishing mortality, HMM is handling molting fishing mortality, and CM is cannibalism induced mortality. Sub indexes indicate key partitions of the data for purposes of analysis where *a, g, t, f, and r* correspond to age, gender, time, fleet, and region.

variation), and molting across time and space for all age classes and males/females. Since there is no direct measurement of biomass for Dungeness crab, nor a known stock recruitment relationship (ODFW 2014), biomass will be a relative index based on the assumption that 90% of recruited males are harvested in a "typical year" (this assumption can be changed in the model). All pre-recruits (1^+, 2^+, 3^+, and 4^+ aged animals) plus older females and recently recruited male animals (5^+ and 6^+) will also be accounted for across weeks and years. Male and female animals 7^+ and older will be aggregated by an accumulator function. New 1+ pre-recruit animals (equally proportioned among male and females) will enter the model the first two week period of each fishing season (Dec 1-15) of each year. To represent a typical year, the first year's biomass structure will be tuned to represent expected biomass generating the mean year's harvest over the last ten years. To represent the general pattern of harvest over a ten year period a "best-fit regression model" will be developed based on an oscillatory time dependent function (for example, sine wave function) to generate numbers of 1^+ animals that would produce harvest and catch per unit effort consistent with observed patterns across time.

2) *Fleet Module*: Past work by members of the research team (see Appendix II) has shown that the Oregon crab fishery is composed of many distinct "fleets" based on their primary fisheries including for example "crab only" fleet, "crab salmon" fleet, "crab-limited entry fixed gear groundfish fleet, "crab open-access fixed gear groundfish fleet, and crab trawl-vessel groundfish fleet. Fleet structure and behavior strongly explains or is correlated with vessel size, profitability of the crab and alternative fisheries, entry/exit behavior, effort levels, etc. All Oregon permitted Dungeness crab vessels will be assigned to a number of fleets (the exact number including an "aggregate" will be determined after reviewing the data). Based on state records, total crab trap permit endorsements will be represented within each class of fleets; total "active" pots will also be calculated for each fleet. Effort will be measured as total "pot soak days" per fleet per two week period. The module will track across time total vessels fishing per fleet and region, total traps, and total effort (pot soak days per two week period).

3) *Economic Module*: Cost and earnings models and profitability, revenues and prices have previously been analyzed for Oregon's Dungeness crab fleets (Appendix II). Costs include annual fixed costs (e.g., vessel and permit loan payment, insurance, moorage fees, gear and traps, annual maintenance, etc.) and trip related variable costs (e.g., fuel, food, bait, crew wages, etc.). Revenue and earnings are a function of catch, effort (pot-soak times), costs, and output prices. The economic module will include an annual two week price model based on historical price patterns (Appendix II) and the seasonal price pattern will be represented by a time dependent equation. While the default model will represent an average annual pattern of prices, the simulation model will allow the parameters in the price model to be adjusted to represent alternative patterns. The module, interacting with the biological and fleet modules, will track total revenue, costs, catch, catch per unit effort, revenue and profitability per pot, and profitability per fleet, vessel, and region over time. The model will exit the fleets from the crab fishery when fleet variable costs exceed revenue, plus an "opportunity cost" where appropriate (when opportunity profits of the fleet's next best fishery exceeds marginal profits by remaining in the crab fishery. The model will aggregate total costs, revenues, and profits for each

year and across all selected years. Net present value (sum of the time stream of discounted profits) will be calculated for each model run using a discount rate (3% default value—other rates can be selected by the model user).

2. Data Collection

Project researches will collect and use data from a variety of sources including published research papers, grey literature and agency reports, fish ticket system data from the PacFIN database (with permission from ODFW), Dungeness crab logbook data (with permission from ODFW), and previously collected data (with source citations) housed in the Research Group, LLC's extensive economic fishery database. Since III.B and III.C projects may not have been completed at the time the model is finalized, we will use discard rates on molted and non-molted crabs, mortality rates, and cannibalism rates for molted and non-molted crab based on available literature, unpublished research (e.g., Yochum, unpublished data), and in consultation with advisors. All data, parameters, variables, and equations used in the model will be defined and the source cited. When expert opinion is used in selecting parameters or equations, justifications will be provided.

3. Model Calibration and Analysis

When the model is completed it will be calibrated to ensure that under existing management conditions it represents the behavior, harvests, revenues, and profitability of the fishery. The model will then be used to evaluate the major objectives and considerations described in Section III.A of the RFP including:

1) Under existing status quo management (typical season and annual patterns of prices, costs, biomass and harvests), analyze the costs, revenues, effort, catch per unit effort, harvest levels, fishing mortality (from all sources), and profitability of the fishery, per two week period, two month period, annually, and across ten years, by fleet and fishing region. Estimate the "costs" of bycatch (foregone profits for each source of bycatch mortality) for each eight week phase of the fishery, annually, and over a ten year period. All major model outputs including costs, revenue, profits, harvests, effort, catch per unit effort, and discard mortality/"costs", will be summarized in output graphs, tables, or charts.

2) Rerun the model and conduct sensitivity analysis for key parameters including discard mortality rates, rates of pot cannibalism, market price patterns, diesel fuel costs, etc. The range of the sensitivity test will depend on the variance or uncertainty associated with each parameter. The range of sensitivity analysis will be selected after consultation with the project steering committee.

3) In collaboration with ODCC, ODFW, and the project steering committee, rerun the model under a range of alternative management tools that may alter the amount and distribution of costs, revenue, landings, profitability, regional economic impacts, and fishing and discard mortality. These tools might include total or bi-monthly effort caps (pots and or vessels), or harvest caps by trip or season, tradable pot quotas, limits on pot soak time, or other management tools. Summarize results in a series of tradeoff curves

for outputs of key interest including profitability vs. fishing mortality, vs. economic distribution of benefits across fleets, regions or time. Use the analysis to search for policy tools that may increase overall economic benefits while limiting economic costs to the fleets and coastal regions.

4. Model Presentation and Workshop

The results of the project will be summarized in a final report and all model data, runs, and outputs will be catalogued and saved on a thumb-drive (or alternatively via a file sharing software such as Drop-Box). The final results will also be presented at a workshop with ODCC and other invited guests. The workshop will include a session to instruct potential users on how to use the model.

B. Steering Committee

We will assist the ODCC establish a steering committee with anticipated representation from the ODCC staff and board, ODFW, other ODCC funded researchers, and other technicians. The steering committee responsibilities would include helping with the organization of an industry/agency workshop meeting at the end of the project. There are two purposes for the workshop. 1) Consultants will present project findings, discuss implications, and discuss ideas for evaluating other management practices or alternative fishery scenarios. 2) Workshop participants will be requested to provide feedback on management strategies for consideration by the ODCC to make recommendations to the ODFW. We aim to work with the steering committee to ensure that the most accurate and up-to-date information is being used in the model, and that the model will meet the requirements of the ODCC and ODFW. The steering committee and workshop approach is intended to increase the likelihood that this model will contribute towards improving management of the fishery.

III. WORKSCOPE AND WORK PLAN

A. Tasks

The project tasks and key personnel assignments are shown in Table 1. The seven task descriptions succinctly explain the steps needed to complete the project. The proposal's previous sections on research methods and the steering committee involvement provided the detail for what each task would accomplish. A following section explains the schedule for carrying out the tasks.

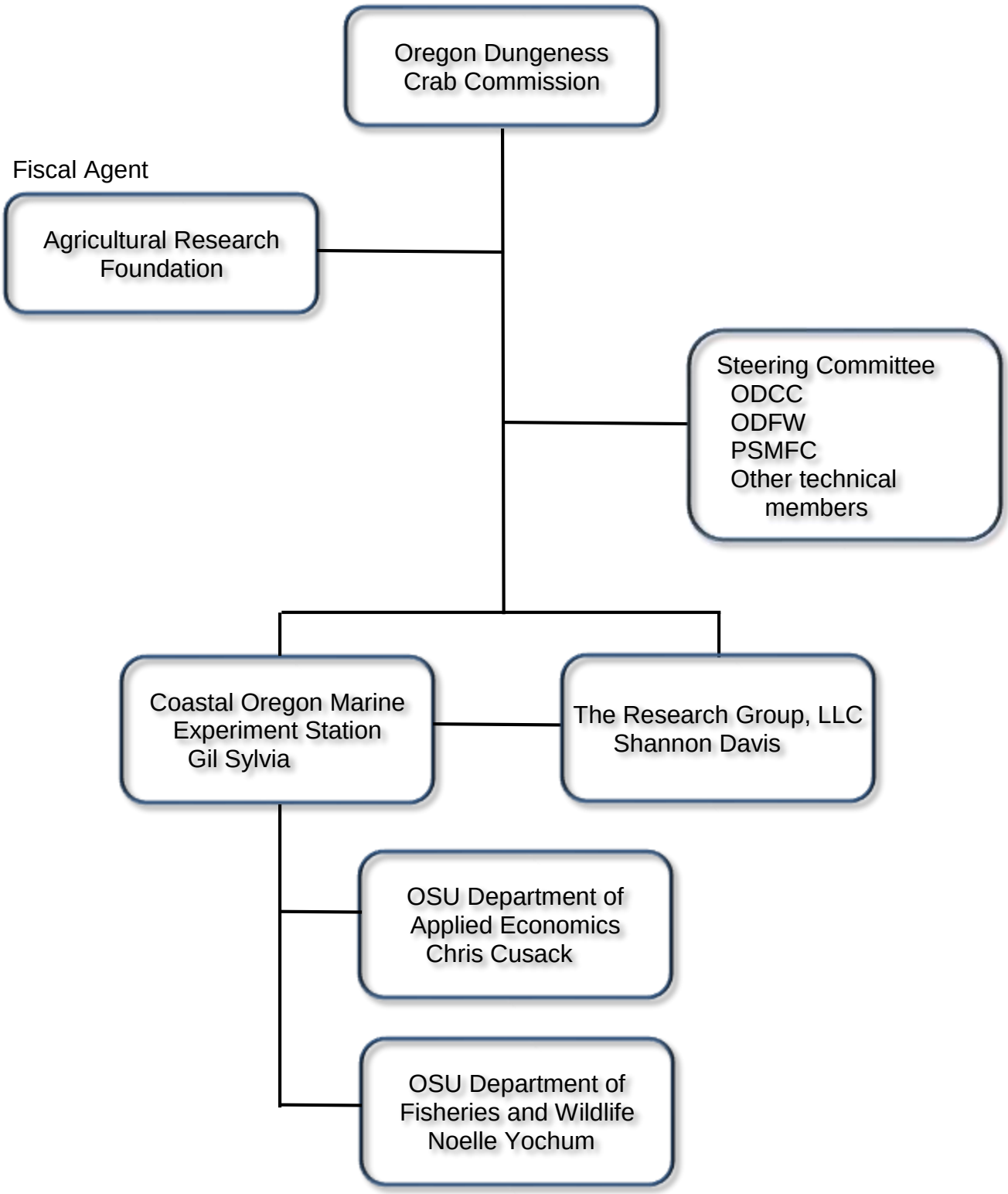
B. Organization

The proposed project organization is shown on Figure 1. The Agricultural Research Foundation (ARF) will be the fiscal agent by holding the prime contract with the ODCC. This will preclude having to reimburse OSU for indirect costs associated with their facility and administrative rate.

Table 1
Task List and Key Personnel Assignments

Tasks	Key Personnel			
	Sylvia	Davis	Yochum	Cusack
1) Characterize Oregon and Pacific West Coast Dungeness crab fishery for management, capital, activity, economic performance, and market situation.	X	X		
2) Acquire logbook, fish ticket system, fleet economic information, biological investigative results, and ecosystem situational data. Summarize relevant literature and ongoing data collection programs. Relate understandings to design of economic and mortality modeling.	X	X	X	X
3) Develop spatial explicit bio-economic model with two week progressions. Incorporate multi-fleet and market demand factors. Link to recruitment and mortality model modules. Test model and show uncertainty of results.	X	X	X	X
4) Develop mortality model to be linked to bio-economic model for testing alteration of bycatch. Handling mortality as function of molt status and cannibalism are two included parameters.	X	X	X	X
5) Apply and assess scenario management strategies to determine industry, market, and community impacts.	X	X		X
6) Establish a project steering committee to meet three times. Facilitate a workshop to explore project scenario results for consideration of recommending new management strategies.	X	X	X	X
7) Attend and speak on project progress at four ODCC meetings. Prepare final workshop report and final technical report.	X		X	

Figure 1
Project Organizational Chart



Also, the ARF does not charge an administrative fee for their services. The Coastal Oregon Marine Experiment Station (COMES) and The Research Group, LLC will subcontract with ARF. The assigned Ph.D. students are employees of the respective OSU departments. OSU will be reimbursed for the student labor budgets by ARF. All team members will be supervised by Dr. Sylvia who is director of COMES.

C. Schedule

We anticipate a 13-month project duration beginning July 2015 (Figure 2). We will begin by developing a bio-economic model that utilizes available data from the literature, fish tickets, and logbooks, as well as unpublished data. The three separate biological, fleet, and economic modules will be linked to an overall interactive model. In the first months of the project, we will assist the ODCC assemble a steering committee.

An initial steering committee meeting with the committee will take place in the summer of 2015. During this workshop we will discuss model design and information input. In the fall of 2015 we will host a second meeting with the committee to collectively evaluate a preliminary model to ensure that the final product will meet the requirements of the ODCC and ODFW. We will also determine if any new data is or will be available that can improve the model. Following this meeting, the model will be calibrated and an updated version will be created. In the winter of 2016 the final model along with an evaluation of its application will be presented at a third steering committee meeting. At this time we will instruct the committee members how to use the computer application (Excel workbook). A workshop with a wider invitation list will be organized and tentatively scheduled to be in held in the spring 2016. The purpose of the workshop is to present project findings and test the plausibility for instituting fishery management practice changes. We will also discuss the model and its applications, and the potential for future work.

To maintain communication with the ODCC and ODFW throughout the project duration, we will also attend the regular ODCC meetings that occur, typically, in September, February, April, and June. The computer application (Excel workbook), operations manual, and final report would be delivered to the ODCC in July 2016.

D. Budget

The proposed budget is shown in Table 2. The budget was carefully prepared to be commensurate with the amount of work we think is necessary to accomplish the project goals as set out by the RFP requirements. However, we are certainly willing to discuss adjustments in the research objectives and budget levels.

The proposed terms are for a cost reimbursable, fixed maximum contract. The labor costs would be fully committed, but the travel costs for meetings and at-sea days and other project-project related expenses can be considered cost reimbursable. With these terms, the ODCC knows that

Figure 2
Project Timeline

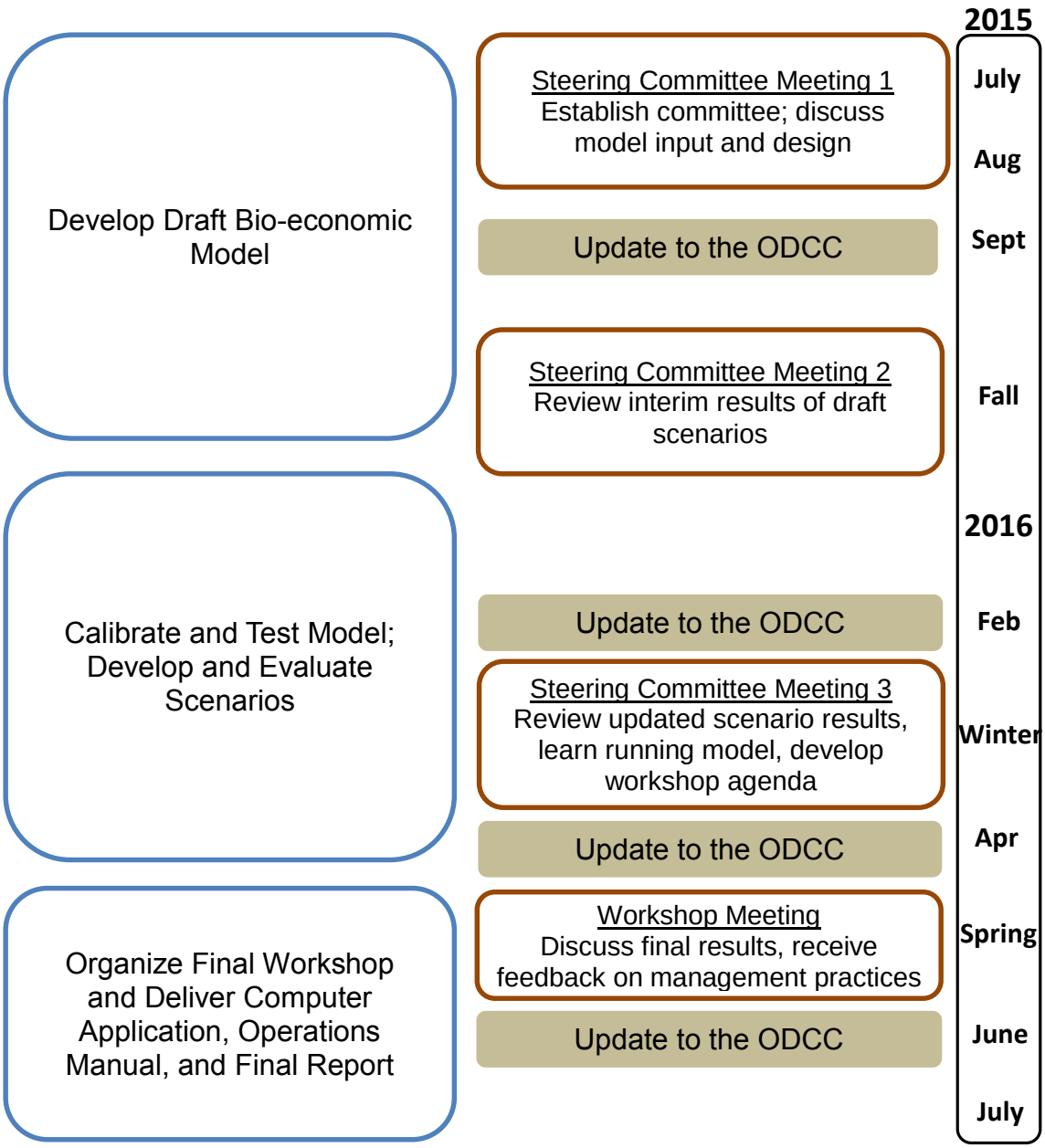


Table 2
Budget Outline

Budget Expenditures	Rate	Hours or Months	ODCC Amount	Match Rate	Match Amount	Total Project
Labor						
Sylvia (Monthly Rate)	$12,634	0.5	$6,317	1.25	$15,793	$22,110
OPE (Benefits)	54%		$3,411		$8,528	$11,939
TRG						
Davis	$100	400	$40,000			$40,000
Research assistant	$50	200	$10,000			
Yochum (GRA .49 FTE Term Rate)	$6,459	1	$6,459			$6,459
OPE (Benefits)	1%		$65			$65
Cusack (GRA .49 FTE Term Rate)	$6,112	1	$6,112			$6,112
OPE (Benefits)	15%		$917			$917
Labor Subtotal			$73,281		$24,320	$97,602
Travel and Per Diem	Per Trip	Trips				
Travel (two-person trips Coos Bay example)	$250	8	$2,000			$2,000
Per diem (2 days per person per trip)	$250	16	$4,000			$4,000
Travel Subtotal			$6,000		$0	$6,000
Other		Terms				
Tuition reimbursement	$5,077	2	$0		$10,154	$10,154
Materials, supplies, other			$719			$719
Other Subtotal			$719		$10,154	$10,873
Total Proposed Budget			$80,000		$34,474	$114,475

Task	Task Budget Share	Task Budget Amount
1	8%	$8,851
2	4%	$4,721
3	65%	$74,349
4	6%	$7,081
5	4%	$4,131
6	3%	$2,950
7	11%	$12,392
Total	100%	$114,475

Note: 1. Labor benefits and department overhead are included in labor rates.

cost savings can occur and the project is guaranteed to be completed within the estimated amount. The proposed budget will remain in effect for 90 days.

This offered proposal represents a certification that the offered team can complete the project within the defined timeframe. Follow-on technical assistance (TA) is offered on a time and materials basis using the labor unit costs showing on Table 1. The proposed budget does not include the purchase of computer software or hardware. It is assumed the final report will be posted on the ODCC website and hard copy printing and distribution is not necessary.

IV. QUALIFICATIONS

A. Team

The project team was put together to have the qualifications for being able to quickly develop an interactive bio-economic model for an Oregon commercial fishery. The project team will be led by Dr. Gil Sylvia, Professor, Department of Applied Economics, Oregon State University. As Director of the Coastal Oregon Marine Experiment Station (COMES), Dr. Sylvia has been involved in commercial fisheries management at the policy level since his tenure began with COMES in 1989. Dr. Sylvia will be in charge of the day-to-day administration of the project. Dr. Sylvia has extensive experience in coordination of large and multifaceted projects similar to this project. Given this is a fast moving project, attention will be paid to tracking the performance of the project in relation to goals, milestones, timetables, and budgets. This will enable the efficient allocation of manpower and monitoring of milestones to ensure effective delivery of project outputs.

Shannon Davis, Principal, The Research Group, LLC will assist Dr. Sylvia for the overall design of the bio-economic model and the software programming to implement the design. Mr. Davis has worked with Dr. Sylvia on many commercial and recreation fishery economics project. Mr. Davis has assisted ODFW for over 30 years in economic and socio-economic data compilation, analysis methods development, and commercial fisheries assessments. The interactive bio-economic model development is similar to Excel-based fishery bio-economic simulation models that have been developed by the authors, for example Sylvia et al. (2012) and Limieux and Sylvia (2003).

Two Ph.D. students will assist Dr. Sylvia and Mr. Davis. Noelle Yochum will assist in the development of the biological module. Chris Cusack will assist in the development of the economics module. Both students will be available to attend steering committee and the workshop meetings.

The above team members have years of familiarity with Dungeness crab fishery and will be able to launch into the project without any learning curve on the biology and management of this fishery.

B. Short Biographies

The project team has unique qualifications to successfully complete this project. The team's work can be expected to provide a novel contribution to the understanding of the extent and economic importance of the Dungeness crab commercial fishery operating under new management strategies. This section of the proposal has short biographies for each of the team members. Full vitaes for the team members are contained in Appendix I.

Gil Sylvia, Ph.D. is currently a professor at the Department of Applied Economics, Oregon State University. He has been Director of the Coastal Oregon Marine Experiment Station, Oregon State University since 1997. Dr. Sylvia is Co-PI on the Community Seafood Initiative, a program initially sponsored by the Kellogg Foundation and USDA which offers assistance to seafood entrepreneurs and small and mid-size businesses throughout the Pacific Northwest. He was co-chair of the W1004 CSREES Fisheries and Aquaculture Resource Marketing and Management Committee. Dr. Sylvia served on a National Research Council Committee on Cooperative Fisheries Research. He has been Associate Editor, Journal of Aquacultural Economics and Management, and Transactions of the America Fisheries Society. Dr. Sylvia has lectured and participated on fisheries management and marketing conferences throughout the world and has participated in education and research projects in North and South America, Asia, New Zealand, and Australia.

Recent example projects include:

- 2005-2015: Co-Leader of Collaboration for Oregon Ocean Salmon and West Coast Genetic Stock Identification. Co-PI with Jeff Feldner, Pete Lawson, Michael Banks, Nancy Fitzpatrick. Funding by Oregon Watershed Enhancement Board and NOAA, $7.5 Million
- 2008-2011 Community Seafood Initiative, Oregon Innovation Council $900,000, Co-Investigator with Michael Morrissey and Diane Moody
- 2006-2009 Enhancing global competitiveness of the U.S. seafood industry, educational case studies in international trade and marketing, Funding USDA CSREES $99,653, Principal Investigator
- 2006-2008 Improving Participation In Fisheries Management: Stock Assessment Training for Stakeholders, Funding Oregon Sea Grant $194,212, Principal Investigator
- 2006-2008 Market Based Environmental Standards for Sustainable Fisheries, Funding Oregon Sea Grant $164,241, Co-Investigator with Michael Harte
- 2002-2006 Bridging the Divide: Integration of Research and Conservation-Based Development, Funding Kellogg Foundation $691,875, Co-Investigator with Michael Morrissey

Shannon Davis is a principal at The Research Group, LLC. Mr. Davis is a systems research specialist with a specialty in econometrics. He has over 30 years of experience in the field of resource economics. His professional interests are in single/multiuse natural resource planning and management with a specialty in resource economic modeling. Mr. Davis served two terms on the Pacific Fishery Management Council (PFMC) Scientific and Statistical Committee.

Mr. Davis has collaborated with other fisheries economists and fisheries management experts on many domestic and international fishery related projects. Recent examples include:

- Estimating economic impacts of Alaska fisheries using a CGE economic model for the NOAA Fisheries Alaska Fisheries Science Center in 2010.
- Development of a Ghana fisheries and seafood bio-economic assessment model for The World Bank in 2011.
- Economic description of the Alaska halibut fishery sector transfers for the National Fish and Wildlife Foundation in 2012.
- Economic assessment of Oregon's proposed marine reserve sizing and siting program for the Oregon Department of Fish and Wildlife in 2013.
- Columbia River avian anadromous fish predation probability economic impact model for the Corps of Engineers in 2014.

Mr. Davis has completed many projects involving resource user surveys, including the Oregon State Parks SCORP in 2002 and 2007. Many of the above mentioned fisheries related economic analysis studies have required access to PacFIN, AKFIN, RecFIN, CWT, PIT, DART, commercial fishing logbooks, and states license and tag recovery programs. TRG has developed a working relationship with database administrators in utilizing these systems. TRG has constructed proprietary relational databases for much of this information for use in special studies.

Noëlle Yochum, an Oregon State University Ph.D. Candidate, will work closely on this project with Dr. Sylvia and Mr. Davis to incorporate data from her previous Oregon Dungeness crab research. She will also provide advice on model development and evaluation based on her first-hand knowledge of the fishery, its management, and related research priorities. Moreover, Ms. Yochum will be involved in organizing a steering committee for this project and in outreach to the fishing community. In 2011, Ms. Yochum was contracted to conduct research on behalf of the ODCC with the goal of contributing to their efforts to obtain Marine Stewardship Council certification. Since then she has had the opportunity to intimately learn about Oregon Dungeness crab and fisheries for them. Prior to working in Oregon, Ms. Yochum has worked on applied fisheries research projects in Mexico, the U.S. east coast, California, and Alaska. She has experience working closely with fisheries managers and the fishing industry to conduct research that improves fisheries management and promotes sustainable fishing practices.

Christopher Cusack is a PhD candidate in the Department of Applied Economics at Oregon State University, Corvallis. His primary interests are bio-economic simulation model building to address problems in the field of fisheries economics. He has extensive experience in fisheries including seven years as a fisheries biologist in the Alaska groundfish fishery and six years of bio-economic modeling experience. Recent work includes a publication on fishery cooperatives in the west coast fishery, primary bio-economic modeler on a Lenfest project studying the impacts of age-structured management in the west coast rockfish fishery, several consulting projects for the Pacific Fishery Management Council and other entities, and several years of work on a dissertation on bio-economic modeling as part of his Ph.D. requirements.

V. LITERATURE CITED

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Yochum, N., et al. 2015. Utilizing reflex impairment to assess the efficacy of the "3-S" management strategy for Oregon Dungeness crab (*Cancer magister*) fisheries. *In preparation.*

APPENDIX I

Vitaes

VITAE
GIL SYLVIA
Professor, Agricultural and Resource Economics
Director, Coastal Oregon Marine Experiment Station
Oregon State University
Hatfield Marine Science Center
Newport, Oregon 97365
(541) 867-0284 (Work) (541) 563-2905 (Home)
(541) 867-0138 (Fax) gil.sylvia@oregonstate.edu (E-mail)

Education

Ph.D. 1989, University of Rhode Island, *Marine Resource Economics*
M.S. 1981, Colorado State University, *Fisheries and Wildlife Biology*
B.S. 1973, University of Massachusetts, *Natural Resources*

Appointments

Professor, Department of Agricultural and Resource Economics, Oregon State University, 2004--present
Director, Coastal Oregon Marine Experiment Station, Oregon State University, 1997--present
Associate Professor, Department of Agricultural and Resource Economics, Oregon State University, 1996--2004
Assistant Professor, Department of Agricultural and Resource Economics, Oregon State University, 1989--1995

Selected Publications

Bellinger, M. R., M. Banks, S. Bates, E. Crandall, J. Garza, G. Sylvia, and P. Lawson. In Press. Geo-Referenced, Abundance Calibrated, Ocean Distribution of Chinook salmon (*Oncorhynchus tshawytscha*) Stocks across the West Coast of North America. *PLoS One.*

Anderson, J., C. Anderson, J. Chu, J. Merredith, F. Asche, G. Sylvia, M. Smith (and 19 others). 2015. The Fishery Performance Indicators: A Management Tool for Triple Bottom Line Outcomes. May 6,DOI: 10.1371.

Sterling, B., Gooch M., Dent B., Maernick, N., Miller, A., and Sylvia, G. 2015. Assessing the Value and Role of Seafood Traceability from an Entire Value-Chain Perspective. *Comprehensive Reviews in Food Science and Food Safety*. 14 (3): 2015-2068.

Fonner, R., and G. Sylvia. 2015. Willingness to Pay for Multiple Seafood Labels in a Niche Market. *Marine Resource Economics* 30 (1): 51-70.

Sylvia, G., Cusack, C., and Swanson. J. 2014. Fishery Cooperatives and the Pacific Whiting Conservation Cooperative: Lessons and application to non-industrial fisheries in the Western Pacific. Marine Policy, Volume 44: 65-71.

Sylvia, G and N. Steinberg. 2012. Development of Electronic Information Systems for Regional and National Fisheries: A Joint Proceedings from Two Workshops—May 3-5, 2011 Portland, Oregon and September 6-7 Seattle Washington.

Larkin, S. , Sylvia, G., Harte, M. 2011. Practical Considerations in Using Bioeconomic Modeling for Rebuilding Fisheries, *OECD Food, Agriculture and Fisheries Working Papers*, No. 38, OECD Publishing.

Larkin, S., Sylvia, G., Harte, M., and K. Quigley. 2007. Optimal Rebuilding of Fish Stocks in Different Nations: Bioeconomic Lessons for Regulators. *Marine Resource Economics*, 21: 395–413.

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Larkin, S. and G. Sylvia. 2000. Firm-Level Hedonic Analysis of U.S. Produced Surimi: Implications for Processors and Resource Managers. *Marine Resources Economics*; 14 (3): 179-198.

Larkin, S. and G. Sylvia. 1999. Intrinsic Fish Characteristics and Intra-Season Production Efficiency: a Management-Level Bioeconomic Analysis of a Commercial Fishery. *American Journal of Agricultural Economics*, 81:29-43.

VITAE

Shannon W. Davis
Principal, The Research Group, LLC
P.O. Box 813
Corvallis, Oregon 97339-0813
Voice and Facsimile: (541) 758-1432, Email: shannond@trgsystems.net

Education

University of Oregon: 1969-72, Bachelor of Science Program
Colorado State University: 1972-74, Masters of Science Program

Relevant Professional Experience:

Mr. Davis is a systems research specialist with a specialty in econometrics. He has over 30 years of experience in the field of resource economics. His professional interests are in single/multiuse natural resource planning and management with a specialty in resource economic modeling. Mr. Davis served two terms on the Pacific Fishery Management Council (PFMC) Scientific and Statistical Committee. Mr. Davis has collaborated with other fisheries economists and fisheries management experts on many domestic and international fishery related projects.

Mr. Davis has completed many projects involving resource user surveys, including the Oregon State Parks SCORP in 2002 and 2007. Many of the above mentioned fisheries related economic analysis studies have required access to PacFIN, AKFIN, RecFIN, CWT, PIT, DART, commercial fishing logbooks, and states license and tag recovery programs. TRG has developed a working relationship with database administrators in utilizing these systems. TRG has constructed proprietary relational databases for much of this information for use in special studies.

Selected projects:

- Oregon Angler Survey, Oregon Department of Fish and Wildlife, 1991.
- "Economic Description of Coastal Fisheries in the Pacific Northwest" and "Economic Description of Coastal Tourism in the Pacific Northwest." Background papers for inclusion in the "Forest Ecosystem Management: an Ecological, Economic and Social Assessment." (Popularly known as President Clinton's Forest Summit), Portland, Oregon. 1993.
- Analysis of Saipan's Seafood Markets for the Commonwealth of Northern Mariana Islands, CNMI Department of Fish and Wildlife, 1994-95.
- Lower Snake River Juvenile Salmon Migration Feasibility Study, Anadromous Fish Economic Analysis, U.S. Army Corps of Engineers, Walla Walla District, 1999.
- West Coast Groundfish Fishery Disaster Assistance Plan, Oregon Coastal Zone Management Association, 2000.

- Economic Evaluation of Control of Noxious Weeds, Oregon Department of Agriculture, 2000.
- Recreational Needs Assessment for the SCORP, Oregon State Parks, 2002 and 2007.
- Northern Pikeminnow Management Program Economic Evaluation Project, Pacific States Marine Fisheries Commission, 2004
- Tribal Salmon Fisheries Marketing Opportunities Study, Northwest Indian Fisheries Commission, 2005.
- Description of the U.S. West Coast Commercial Fishing Fleet and Seafood Processors, Pacific States Marine Fisheries Commission. 2006.
- Select Area Fisheries Evaluation Project Economic Evaluation, Bonneville Power Administration, 2006.
- Economic analysis of Puget Sound Chinook Management Plan EIS, NMFS, 2007.
- Developing an economic model using results from the West Coast FEAM to analyze management alternatives for the West Coast Essential Fish Habitat EIS, PFMC, 2008.
- Estimating economic impacts of Alaska fisheries using a CGE economic model for the NOAA Fisheries Alaska Fisheries Science Center in 2010.
- Development of a Ghana fisheries and seafood bio-economic assessment model for The World Bank in 2011.
- SE Alaska Cost-Earnings, NMFS Alaska Science Center, 2011.
- Economic description of the Alaska halibut fishery sector transfers for the National Fish and Wildlife Foundation in 2012.
- Economic assessment of Oregon's proposed marine reserve sizing and siting program for the Oregon Department of Fish and Wildlife in 2013.
- Economic impact of selected noxious weeds in Oregon, Oregon Department of Agriculture, December 2014.
- Columbia River avian anadromous fish predation probability economic impact model for the Corps of Engineers, Portland District in 2015.

Selected Publications (since 2005):

1. The Research Group. Black and Blue Rockfish Fishery Economic Sustainability. Letter report to Patty Burke, Marine Program Manager, Oregon Department of Fish and Wildlife. August 8, 2005.
2. The Research Group. A Demographic and Economic Description of the Oregon Coast: 2006 Update. Prepared for Oregon Coastal Zone Management Association. March 2006.
3. The Research Group. Review of the West Coast Commercial Fishing Industry in 2004. Prepared for Pacific States Marine Fisheries Commission. September 2006.
4. The Research Group. Select Area Fishery Evaluation Project, Economic Analysis Study, Final Report. Prepared for Bonneville Power Administration, Washington Department of Fish and Wildlife, and Oregon Department of Fish and Wildlife. November 2006.
5. The Research Group. Commercial Fishing Economic Effects Variability for the West Coast Salmon Fishery. Letter Report to Frank Warrens, Chairman Marine Reserves Working Group, Oregon Ocean Policy Advisory Council. May 10, 2007.

6. The Research Group. Estimating Economic Impacts of Alaska Fisheries Using a Computable General Equilibrium Model, Data Acquisition and Reduction Task Documentation. Draft. Prepared for National Marine Fisheries Service and Alaska Fisheries Science Center. November 2007.
7. The Research Group, Corvallis, Oregon in association with TCW Economics, Sacramento, California. Washington Commercial Fisheries Economic Value in 2006. Prepared for Washington Department of Fish and Wildlife (WDFW). December 11, 2008.
8. The Research Group. Mitchell Act Hatchery EIS, Preliminary 2.1, Economic and Social Analysis Sections. Prepared for NOAA Fisheries, Northwest Regional Office Salmon Recovery Division, Portland, Oregon. January 2009.
9. The Research Group. North Pacific Salmon Fisheries Economic Measurement Estimates. Prepared for Wild Salmon Center, Portland, Oregon. December 2009.
10. Sylvia, Gil and Shannon Davis. Fishery Performance Indicator Project West Coast Dungeness Crab Fishery Case Study. Draft. May 2011.
11. SylDon Inc. Ghana Artisanal Marine Sector Case Study Results, Ghana Fisheries and Seafood Bio-economic Assessment Model Project. Prepared for New Partnership for Africa's Development, Johannesburg, South Africa. June 2011.
12. The Research Group. Bering Sea Aleutian Island Crab Rationalization Management Program, Five Year Review Industry Response. Alaska Bering Sea Crabbers Proposals, Investigation and Economic Analysis. Prepared for Alaska Bering Sea Crabbers, Seattle, WA. December 2011.
13. Sylvia, Gilbert, Ph.D. Data Requirements for Developing and Operating a Bioeconomic Model Used in Economic Assessment of a Region's Seafood Industry. Prepared for West Africa Regional Fisheries Program, The World Bank, Washington D.C. and Food and Agriculture Organization of the United Nations. January 2012.
14. Waters, Edward, Ph.D. and The Research Group. Regional Economic Data Collection Project for Southeast Alaska. Prepared for Alaska Fisheries Science Center. April 2012.
15. SylDon Inc. Operational Guide, Ghana Fisheries and Seafood Bio-economic Assessment Model. Prepared for New Partnership for Africa's Development, Johannesburg, South Africa. June 2012.
16. The Research Group, LLC and Golden Marine Consulting. Using Spatial Analysis of Fisheries and Habitat Data to Evaluate Economic Effects of Oregon Marine Reserve Sites. Prepared for Marine Resources Program, Oregon Department of Fish and Wildlife. June 2012.
17. The Research Group. Port of Newport's Strategic Business Plan and Capital Facilities Plan, Commercial Fishing Industry Description. December 31, 2012.
18. The Research Group, LLC. Oregon Marine Recreational Fisheries Economic Contributions in 2011 and 2012. Prepared for Oregon Department of Fish and Wildlife and Oregon Coastal Zone Management Association. July 2013.
19. Davis, Shannon, Gilbert Sylvia, and Chris Cusack. Economic Implications of a Strategy to Purchase Alaska Halibut Fishery Commercial Fishing Sector Quota Shares to Create a Recreational Guided Angler Sector Harvest Common Pool. Prepared by The Research Group, LLC, Corvallis, Oregon for the CATCH Project, Auke Bay, Alaska. August 2013.

20. The Research Group, LLC. Oregon's Commercial Fishing Industry, Year 2011 and 2012 Review. Prepared for Oregon Department of Fish and Wildlife, and Oregon Coastal Zone Management Association. September 2013.
21. The Research Group, LLC. The Economic Contribution From Ocean Research, Planning, and Management Activities at Port Orford, Oregon. Prepared for Oregon Department of Fish and Wildlife and Port Orford Ocean Resources Team. October 2013.
22. The Research Group, LLC. Economic Impacts of the Proposed Catch Limit Alternatives for the Oregon Commercial Halibut Fishery in 2014. Prepared for Marine Resources Program, Oregon Department of Fish and Wildlife. December 2013.
23. The Research Group, LLC with assistance from the Coastal Oregon Marine Experiment Station. Oregon Commercial Fishing Industry in 2013, Briefing Report. Prepared for Oregon Department of Fish and Wildlife and Oregon Coastal Zone Management Association. March 2014.
24. The Research Group, LLC. Economic Effects and Social Implications Section Double Crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary. Corps of Engineers, Portland District. April 2014.
25. The Research Group, LLC. Economic Implications of the Coastal Multi-Species Conservation and Management Plan. Prepared for Wild Salmon Center, Portland, Oregon. May 2014.
26. The Research Group, LLC. Economic Analysis Update of Noxious Weeds' Impacts in Oregon. Prepared for Oregon Department of Agriculture, Plant Division, Noxious Weed Control Program. December 2014.
27. The Research Group, LLC. Ten Year Update on Lincoln County, Oregon's Economy. Prepared for Lincoln County Board of Commissioners, Newport, Oregon. August 2014.
28. The Research Group, LLC. Oregon Nearshore Strategy Document Update, Social and Economic Analysis Chapters. Prepared for Oregon Department of Fish and Wildlife. June 2015.

Noëlle Yochum

2030 SE Marine Science Dr. • Newport, OR 97365 • (916) 719-5920 • Noelle.Yochum@oregonstate.edu

EDUCATION

January 2010 - Present — *Oregon State University (Corvallis, OR)*

Ph.D. candidate, Fisheries Science
Major advisor: Dr. David Sampson

December 2006 — *College of William and Mary (VIMS; Gloucester Point, VA)*

M.S. Marine Science
Thesis title: "Size-selectivity of the commercial sea scallop (*Placopecten magellanicus*) dredge"
Major advisor: Dr. William DuPaul

June 2003 — *University of California, San Diego (La Jolla, CA)*

B.S. Biology; **Minor: French literature**

SELECTED RESEARCH EXPERIENCE

2010 - Present	**Graduate Research Assistant**, *Oregon State University* Supervisor: Dr. David Sampson
2011	**Fisheries Biologist**, *NOAA/ Alaska Fisheries Science Center* Supervisor: Dr. Craig Rose
2007 - 2009	**Research Technician**, *Moss Landing Marine Laboratories/ CA Sea Grant, and the CA Collaborative Fisheries Research Program* Supervisor: Dr. Richard Starr
2007	**Technician**, *Virginia Institute of Marine Science (College of William and Mary), and the Long-Term Ecological Research Program, Antarctica* Supervisor: Dr. Hugh Ducklow
2004 - 2007	**Graduate Research Assistant**, *Virginia Institute of Marine Science (College of William and Mary)* Supervisor: Dr. William DuPaul
2003	**Technician**, *Scripps Institution of Oceanography* Supervisor: Dr. Kenneth Smith

SELECTED FUNDING

2013	Oregon Dungeness Crab Commission Grant ($25,600)
2012	NOAA/ NMFS Office of Sustainable Fisheries Bycatch Reduction Engineering Program Award ($68,289)
2012	Mamie Markham Research Award ($10,000)
2012	H. Richard Carlson Memorial Scholarship ($3,000)
2012	Oregon Dungeness Crab Commission Grant ($42,413)
2010	Collaborative Fisheries Research Graduate Fellowship ($76,019)

PEER-REVIEWED JOURNAL ARTICLES

- Starr, R.M., D.E. Wendt, C.L. Barnes, C.I. Marks, D. Malone, G. Waltz, K.T. Schmidt, J. Chiu, A.L. Launer, N.C. Hall, and **N. Yochum**. 2015. Variation in responses of fishes across multiple reserves within a network of marine protected areas in temperate waters. PLoS ONE 10(3): e0118502. doi:10.1371/journal.pone.0118502.

- **Yochum, N.,** C.S. Rose, and C.F. Hammond. 2014. Evaluating the flexibility of a reflex action mortality predictor to determine bycatch mortality rates: a case study of Tanner crab (*Chionoecetes bairdi*) bycaught in Alaska bottom trawls. Fisheries Research 161: 226-234.
- **Yochum, N.,** R.M. Starr, and D.E. Wendt. 2011. Utilizing fishermen knowledge and expertise: keys to success for collaborative fisheries research. Fisheries 36 (12): 593 – 605.
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ORGANIZED CONFERENCE SYMPOSIA

- **N. Yochum**, P. He, D. Rudders, L. Benaka, and D. Orner. 2015. Exploring the benefits of collaborative fisheries research and conservation engineering to reduce bycatch and bycatch mortality. 145th Annual Meeting of the American Fisheries Society. Portland, OR (in progress).
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- D. Rudders and **N. Yochum**. Commercial shellfisheries. 104th Annual Meeting of the National Shellfisheries Association. Seattle, WA.

SELECTED INVITED PRESENTATIONS

- **Yochum, N.** 2015. Evaluating Dungeness crab (*Cancer magister*) bycatch in Oregon fisheries. Lummi Natural Resources: Harvest Management. March 6, 2015. Bellingham, WA.
- **Yochum, N.** 2015. Evaluating Dungeness crab (*Cancer magister*) bycatch in Oregon fisheries. Oregon Dungeness Crab Commission. February 17, 2015. Newport, OR.

- **Yochum, N**. 2009. CA Collaborative Fisheries Research Program: marine protected area monitoring. CSUMB Science and Environmental Policy Seminar Series. October 19, 2009. Monterey, CA.
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SELECTED CONTRIBUTED CONFERENCE PRESENTATIONS

- **Yochum, N.,** C. Rose, and C. Hammond. 2014. Evaluating the flexibility of a reflex action mortality predictor to determine bycatch mortality rates: a case study of Tanner crab (*Chionoecetes bairdi*) bycaught in Alaska bottom trawls. 29th Lowell-Wakefield Fisheries Symposium. May 13-16, 2014. Anchorage, AK.
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- **Yochum, N.,** R. Starr, and D. Wendt. 2010. Reaping the rewards of collaboration: fishermen, scientists, and managers develop and implement surveys to monitor California nearshore fishes. 16th Western Groundfish Conference. April 26-30, 2010. Juneau, AK.
- **Yochum, N.** and W.D. DuPaul. 2007. Size-selectivity of the commercial Northwest Atlantic sea scallop dredge. 16th International Pectinid Workshop. Halifax, Nova Scotia, Canada. May 11 – 18, 2007.

SELECTED POSTER PRESENTATIONS

- **Yochum, N.,** A. Stoner, C. Rose, and D. Sampson. 2013. Estimating Dungeness crab (*Metacarcinus magister*) bycatch mortality rates in Oregon fisheries. Heceta Head Coastal Conference 9th Annual Meeting. October 25-26, 2013. Florence, OR.
- **Yochum, N.,** A. Stoner, C. Rose, and D. Sampson. 2013. Estimating Dungeness crab (*Metacarcinus magister*) bycatch mortality rates in Oregon fisheries. American Fisheries Society 143rd Annual Meeting. September 8-12, 2013. Little Rock, AR.
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SELECTED PROFESSIONAL SERVICE

2013 - Present	**Team member and interviewer**, *Voices from the Fisheries*
2012 - Present	**Board member**, *Newport Fishermen's Wives*
2010	**Team member,** *Cape Falcon Marine Reserve Community Team*

SKILLS & CERTIFICATIONS

- Proficient in:
  - R- Statistical Program, SYSTAT, and ArcGIS
  - Website design (Kompozer; HTML)
  - Database creation and management (Microsoft Access)
  - Microsoft Office: Excel, PowerPoint, and Word
- First Aid and US Coast Guard approved Marine Safety and Cold Water Survival Training

Christopher Inju Cusack

3544 SE Shoreline Dr., Corvallis, OR, 97333
541-207-5671
cusackc@onid.orst.edu

Summary

- Current PhD candidate, department of applied economics, Oregon state university. Area of concentration: The economics of fisheries and natural resources. Research interests include the use of bio-economic modeling techniques to compare the economic consequences of management actions, fisheries development economics.
- Extensive hands-on fishing industry experience gained from previous employment as a federal groundfish observer, fisherman, and cannery worker.

Education

PhD Candidate *2007-Present*
Department of Applied Economics, Oregon State University, Corvallis, Oregon.

BSc Honors degree: Oceanography with marine biology. *2001*
University of Southampton, Southampton, United Kingdom

Completion of Advanced Level Certificates: Biology, Chemistry, Mathematics. *1997*
Greshams School, Holt, Norfolk, United Kingdom.

Career History

Graduate Research Assistant, Oregon State University. *2007-Present*

Performed high-quality, independent research on a number of fisheries related projects.

Current research:

- Bioeconomic model building and research to investigate the impacts of spatial fisheries management on fishermen behavior and stock characteristics.
- Background research, data collection, model design and execution for an interdisciplinary project investigating potential biological and economic impacts of different stock assessment techniques.

Previous work includes:

- Research and analysis of quota auctions as a means of distributing catch shares in the U.S. west coast groundfish trawl rationalization
- A review of resource rents in fisheries and how governments may address the issue of rent collection.
- Preparation of a report for the Oregon Invasive Species council entitled: 'The Economics of Invasive Species".

Federal Groundfish Observer/ Marine Biologist, Saltwater Inc., 733 N St., Anchorage, Alaska, 99501 *2001-2008*

- Worked independently on fishing vessels and plants in the Bering Sea and North Pacific Ocean.

Collected biological samples from catch, estimates of catch size and composition, marine mammal and avian samples, observed fishermen for compliance with fishery regulations, prepared data reports for NOAA fisheries.

Publications & Memberships

- Contributing author: Sylvia, Gil, Chris Cusack, and Josh Swanson. "*Fishery cooperatives and the Pacific Whiting Conservation Cooperative: Lessons and application to non-industrial fisheries in the Western Pacific.*" *Marine Policy* 44 (2014): 65-71.
- Lead author of "*The economics of invasive Species*" A report prepared for the Oregon Invasive Species Council, July, 2008.
- Contributing author of "*Economic and Policy Analysis of a Fixed Term Auction-Based Individual Fishing Quota proposal for the West Coast Limited Entry Groundfish Trawl Fishery*" A report prepared for the Pacific Fishery Management Council, September, 2008.
- Member of the International Institute for Fisheries Economics and Trade.

APPENDIX II

Dungeness Crab Commercial Fishery Economic Description

Oregon Dungeness Crab Commercial Fishery Economic Description

The Research Group, LLC

June 2015

Introduction

The Oregon Dungeness commercial crab fishery typically has harvest value that is about one-quarter of all West Coast states, British Columbia, and Alaska Dungeness crab fisheries (Figure 1 and 2) (Sylvia and Davis 2011). The fishery is very important to communities on the Oregon Coast. The fishery alone generated $69.6 million in personal income (includes the "multiplier" effect) for the coastal economy in 2014 (TRG 2015). It is the primary source of revenue for many vessels in Oregon's fishing fleet. It fills what would be downtime in processor through-puts, allowing the companies to provide year around operations. Dungeness crab is an iconic retail product and Oregon Coast visitors have expectations for it being a fresh seafood restaurant menu and store item. There is also an active crab sport fishery that takes place mainly in bays.[1]

The following sections discuss Oregon landing trends, fleet and processor participation, and fishery performance evaluations. The information is from pulling together existing data and study results. The data and study results may have different baseline and trend ending years. The reader is cautioned that sometimes annual average and summed information is for seasons (i.e. Dungeness crab fishery traditional December 1 through August 14 period) and other times for calendar years. The former is more applicable when singularly assessing the Dungeness crab fishery. The latter is more appropriate when comparing and contrasting the multiple commercial fisheries taking place on the Oregon Coast. Except when noted on tables and figures, historical revenue and price data has been adjusted to 2014 dollars using the Gross Domestic Product Implicit Price Deflator developed by the U.S. Bureau of Economic Analysis.

Landing Trends

The Oregon Dungeness crab fishery accounted for about one-third of all the onshore harvest value over the five years ending in calendar year 2014. But the ocean fishery typically has cyclical abundance trends causing high catch variability.[2,3] Crab volumes reached a historic peak in 2006 (somewhat due to the anomaly of shifting December 2005 season into the early months of 2006). The landings decreased through 2008 and bumped up again in 2009. Landings decreased in Year 2010 and were about the same in 2011, however Year 2012 was a 14 year low, followed by the highest volume since 2006 in 2013, then 11.9 million pounds in 2014. The large

1. Ainsworth et al. (2012) estimated there are 130 thousand annual trips in Oregon's bays and the ocean.
2. A University of Oregon report (Ross 2007) discusses the low Dungeness crab larvae production that the waters off Oregon experienced in 2007. This foreshadowed the adult recruitment into the fishery in recent years.
3. There is a smaller commercial bay crab fishery which operates under different season and gear restrictions than does the ocean fishery. Any commercial vessel can participate in the bay crab fishery. The number of vessels making bay crab landings by estuary in 2008 are: five vessels in Yaquina Bay, nine vessels in Alsea Bay, two in Winchester Bay, two landing at Pacific City, two at Garibaldi, two at Florence, and eight at Charleston.

swing in crab landings is revealed by comparing years 2006 when 33.3 million pounds were landed to 2012 when 8.7 million pounds were landed.

Because of the high volume of Dungeness crab, the total landed ex-vessel value was a record $61.5 million in 2006 (Table 1). The value decreased to $30.0 million in 2012 then rose to a new record $72.3 million in 2013 and fell to $48.0 million in 2014.

Landings occur at many of Oregon ports (Table 2). The ports with the greatest engagement in 2014 were Newport (34.1 percent), Coos Bay (24.3 percent), and Astoria (22.6 percent). Of the ports landing $1 million harvest value or more in 2014, the highest dependency on Dungeness crab were Winchester Bay (78.0 percent), Tillamook/Garibaldi (56.4 percent), and Port Orford (43.2%). The crab fishery landings are an important complementary product flow at many other smaller landing ports along the Oregon Coast.[1]

Crab prices were strong at $2.81 and $2.58 in 2000 and 2001, but decreased to less than $2.00 in the middle 2000's. Average calendar year prices increased to $2.77 and $4.03 in 2013 and 2014, respectively. Crab prices also vary considerably over the season, and are opposite to salmon's price variation (Figure 3).

Legislation (Senate Bill 673) passed in Oregon in 2003 to exempt fishing organizations from anti-trust laws has been used in the crab and shrimp fisheries to negotiate a price for season openings. This has precluded strikes by harvesters used in the past for price negotiations. These pre-season agreements have assisted in stabilizing a dependable product flow to markets.

Markets

Crab prices at the start of the season are at their lowest when production is oriented towards the West Coast retail market for whole-cooked product form. After the first of the year, prices increase and the production switches to a section product form for the national food service market. A market substitute for this product form is snow crab harvested in Alaska and Canada. However, Dungeness crab supply will overwhelm the effects of substitute products. Supply shortage will increase prices and high volume will decrease prices (Sackton 2014).

Dungeness crab is a specialty product suited for holidays and special events such as the Super Bowl game. Sections for the restaurant trade and ultimately picked meat is a growing trend. Picking crab for meat is a labor intensive undertaking. U.S. processors of crab will ship containers of whole cooked crab to China and meat will be returned to the U.S. for domestic and export sales. Because the imported product is twice frozen, the final product may not be of the same quality as that which is processed on the West Coast. The live product form market for the Asian ethnic market has also developed to use a small share of the total landed volume. The live product form market does pressure prices to be higher, but the Chinese market is volatile. Live product form exports to China decreased in 2014 over 2013.

1. A port's engagement is defined to be the proportion of Oregon Dungeness crab ex-vessel revenue landed at the port. A port's dependency on Dungeness crab is defined to be the proportion of all fisheries ex-vessel revenue landed at the port that was from the Dungeness crab fishery.

Fleet and Processor Participation

The resource supply of Dungeness crab and declining access to other fisheries has put increased reliance on this species for vessels to maintain revenue streams. This resulted in an increased number of pots used to harvest crab (Figures 4 and 5). A three tier (200, 300, and 500) pot limitation program was instituted for the 2006/2007 season to help control the fishing pressure.

There were initially 464 vessels qualified to hold permits when limited entry was initiated for this fishery in 1995. There are currently 424 permits. The limited entry and three tiered system was designed to stabilize an overcapitalized fishery.

Participants in the crab fishery also participate in other fisheries (Table 3). For example, of the 338 vessels that harvested at least $500 Dungeness crab in 2012, 39 percent (131 divided by 338) of them also harvested at least $500 in albacore tuna, 17 percent of them also harvested at least $500 Pacific halibut, and 27 percent of them also harvested at least $500 troll salmon. (It is not possible to discern in Table 3 how many vessels participated in all four of these example fisheries.) The crab fishery along with the albacore tuna fishery "soak up" the capital exposed from lower other fishery opportunities such as in the salmon fishery. A decline in the availability of the crab resource will create problems for the industry if other fisheries are not in a compensating upswing.

There were 348 vessels (94 percent of all vessels making Dungeness crab deliveries and 82 percent of those with permits) that delivered more than $500 Dungeness crab in 2014 (Table 4). Their average crab revenue was $137,892, which was about 52 percent of their total fisheries revenue. The average crab revenue for the top 10 vessels was $592,286 and their dependency on crab revenue was 63 percent. The top 70 (19 percent) vessels harvested 50 percent of this fishery's total value. The bottom 145 vessels (i.e. 348 minus 203 vessels or 42 percent of all vessels delivering more than $500) harvested 10 percent of the total value.

The crab fishery is prosecuted by a variety of vessel types using type classifications based on fishery participation strategies. (The strategy type classification rules are shown on Table 6.) Table 5 shows the crab fishery highliners have their own strategy classification called "crabbers." Sixty percent of the crab revenue was landed by these vessels in 2010. These vessels harvested 38 percent of all onshore landings in 2010. The next highest landings vessel type is a "large groundfish trawler" followed by "shrimper" followed by a "sablefish fixed gear" vessel type.

Figure 6 shows the annual exit and entry of permitted vessels over the last five years. Approximately 17 percent of vessels either leave or come back into the fishery each year. There is a large cache of vessels that fished all five years (42 percent). This would characterize the fishery as a staple rather than opportunistic fishery.

There were 74 first-buyers of Dungeness crab on the Oregon Coast in 2014. Of the 10 businesses that bought over a $1 million each, they purchased 80 percent of all Dungeness crab harvested. The balance of first-buyer numbers were smaller local processors, brokers, food service businesses, etc. There are a few vessels at ports that will direct sell their catch to the public. The higher volume buyers are processors who will buy at several locations along the

Oregon Coast and haul the crab to a centralized facility for processing and warehousing. These processors are operating year-around and do not specialize in any one fishery. The Dungeness crab fishery season start-up in December helps fill an operational time period when other fisheries have shut down.

Performance Evaluation

The Oregon Dungeness crab fishery is one of 205 global (as of September 2013) certified fisheries by the Marine Stewardship Council (MSC). Oregon Dungeness crab was certified in December 2010. The certification can have benefits from consumer awareness for product quality and resource sustainability. The ODCC decided to allow the certification to expire in November 2015. Despite favorable findings by the MSC for it being a sustainable managed fishery with no evidence of overfishing and products having high market awareness and acceptance, Anderson et al. (2015) found wealth performance improvements could be made through changed management practices.

Table 1
Oregon Dungeness Crab and Total Onshore Landing Volume and Value From 2006 to 2014

	D. Crab			D. Crab Share		Total Onshore	
Year	Volume	Value	Price	Volume	Value	Volume	Value
2006	33,316	61,473	1.85	11%	51%	300,543	119,881
2007	17,026	42,511	2.50	6%	40%	270,997	106,237
2008	13,888	31,839	2.29	7%	29%	204,765	109,555
2009	21,854	45,932	2.10	10%	41%	210,811	110,898
2010	15,868	35,041	2.21	7%	32%	216,618	110,214
2011	17,260	46,855	2.71	6%	31%	285,821	153,582
2012	8,666	29,984	3.46	3%	23%	306,716	130,150
2013	26,073	72,263	2.77	7%	40%	349,390	180,023
2014	11,915	47,988	4.03	4%	31%	300,362	156,127

Notes: 1. Landings volume is reported in thousands of round pounds. Value is in thousands of 2014 real dollars adjusted using the GDP implicit price deflator developed by U.S. Bureau of Economic Analysis.
2. Table shows calendar year landings.

Source: TRG (2015).

Table 2
Harvest Values by Port for Dungeness Crab and All Onshore Landings in 2014

Port Group	County/Port	D. Crab	Engagement	All Onshore	Dependency
Oregon	All	47,988,488	100.0%	156,126,825	30.7%
Astoria	Clatsop	10,889,022	22.7%	48,254,850	22.6%
	Astoria	10,855,289	22.6%	42,721,777	25.4%
	Gearhart/Seaside	33,733	0.1%	172,947	19.5%
Tillamook	Tillamook	2,061,978	4.3%	3,776,174	54.6%
	Nehalem	13,534	0.0%	13,534	100.0%
	Tillamook/Garibaldi	2,019,796	4.2%	3,578,793	56.4%
	Pacific City	28,648	0.1%	153,702	18.6%
Newport	Lincoln	16,382,390	34.1%	52,755,723	31.1%
	Depoe Bay	3,082	0.0%	64,565	4.8%
	Newport	16,348,381	34.1%	52,571,584	31.1%
	Waldport	30,927	0.1%	117,621	26.3%
Coos Bay	Coos	14,479,721	30.2%	37,895,548	38.2%
	Florence	10,796	0.0%	72,745	14.8%
	Winchester Bay	2,817,903	5.9%	3,612,890	78.0%
	Coos Bay	11,651,011	24.3%	34,132,172	34.1%
	Bandon	11	0.0%	77,741	0.0%
Brookings	Curry	4,175,377	8.7%	13,444,530	31.1%
	Port Orford	1,459,048	3.0%	3,377,536	43.2%
	Gold Beach	16,624	0.0%	274,746	6.1%
	Brookings	2,699,705	5.6%	9,792,248	27.6%

Notes: 1. Ports with no Dungeness crab landings, such as Columbia River ports, are not itemized. They are included in port group and Oregon totals.

Source: TRG (2015).

Table 3
Oregon Dungeness Crab Vessel Counts by Active Fisheries Participation in 2012

Fishery	Vessels	Percent
D. crab	338	100%
Salmon		
Net	4	1%
Troll	91	27%
P. shrimp	37	11%
A. tuna	131	39%
Groundfish		
LE	58	17%
OA	54	16%
P. whiting	4	1%
P. sardine	3	1%
P. halibut	56	17%
Other	19	6%

Notes: 1. Active fisheries are defined as $500 minimum onshore harvest value for a vessel in each fishery. The $500 filter should not be interpreted as an indicator for a vessel's targeted fisheries participation.
2. Vessels with identifier that starts with "ZZ" or "NONE" are not included.
3. Columns are not additive because a vessel may participate in more than one of the fisheries in addition to the Dungeness crab fishery. The table only shows counts for Dungeness crab and one single fishery active vessels participation.

Source: TRG (September 2013).

Table 4
Dungeness Crab Fishery Characteristics in 2014

Volume (thousands pounds)		11,915
Price		$4.03
Ex-vessel value (thousands)		$47,988
Change from 2013		-34%
3 year average		-3%
10 year average		7%
Economic contribution (millions)		$69.62
Share onshore total		24%
	Count	Share
Vessels >$500	348	94%
Average crab revenue	$137,892	
Crab share		52%
Vessels 50% value	70	19%
Vessels 90% value	203	55%
Top 10 vessels	10	3%
Average crab revenue	$592,286	
Crab share		63%
Permits authorized	464	
Permits	424	

Notes: Some vessels land outside Oregon, but only Oregon landings are included.
Source: TRG (2015).

Table 5
Oregon Dungeness Crab Vessels by Vessel Category in 2010

		Oregon D. Crab		All WOC		Category
FEAM Vessel Category	Vessels	Revenue	Share	Revenue	Share	Amount
Crabber	208	19,711,359	60.2%	30,307,355	37.8%	65.0%
Less than 40 feet	69	4,233,952	12.9%	5,478,825	6.8%	77.3%
40 to 50 feet	75	6,499,535	19.8%	9,369,740	11.7%	69.4%
Greater than 50 feet	64	8,977,872	27.4%	15,458,790	19.3%	58.1%
Sablefish fixed gear	38	3,110,875	9.5%	11,154,620	13.9%	27.9%
Large groundfish trawler	29	3,676,521	11.2%	15,244,759	19.0%	24.1%
Other <= $15 thousand	27	137,268	0.4%	165,751	0.2%	82.8%
Shrimper	20	3,227,230	9.9%	10,571,353	13.2%	30.5%
Alaska fisheries vessel	20	584,665	1.8%	3,420,454	4.3%	17.1%
Migratory liner	8	793,221	2.4%	1,713,144	2.1%	46.3%
Other groundfish fixed gear	6	99,773	0.3%	484,572	0.6%	20.6%
Pacific whiting onshore and offshore trawler	5	797,749	2.4%	3,364,598	4.2%	23.7%
Other > $15 thousand	4	272,002	0.8%	1,280,934	1.6%	21.2%
Pelagic netter	3	288,377	0.9%	2,368,983	3.0%	12.2%
Salmon netter	c	12,921	0.0%	59,180	0.1%	21.8%
Salmon troller	c	6,145	0.0%	16,997	0.0%	36.2%
Small groundfish trawler	c	28,097	0.1%	66,454	0.1%	42.3%
Total	373	32,746,203	100.0%	80,219,154	100.0%	40.8%

Notes: 1. Counts with a "c" are not shown to avoid revealing confidential information.
2. Vessels with identifier that starts with "ZZ" or "NONE" are not included.
3. All WOC is U.S. West Coast onshore landings from all fisheries by Oregon Dungeness crab vessels.

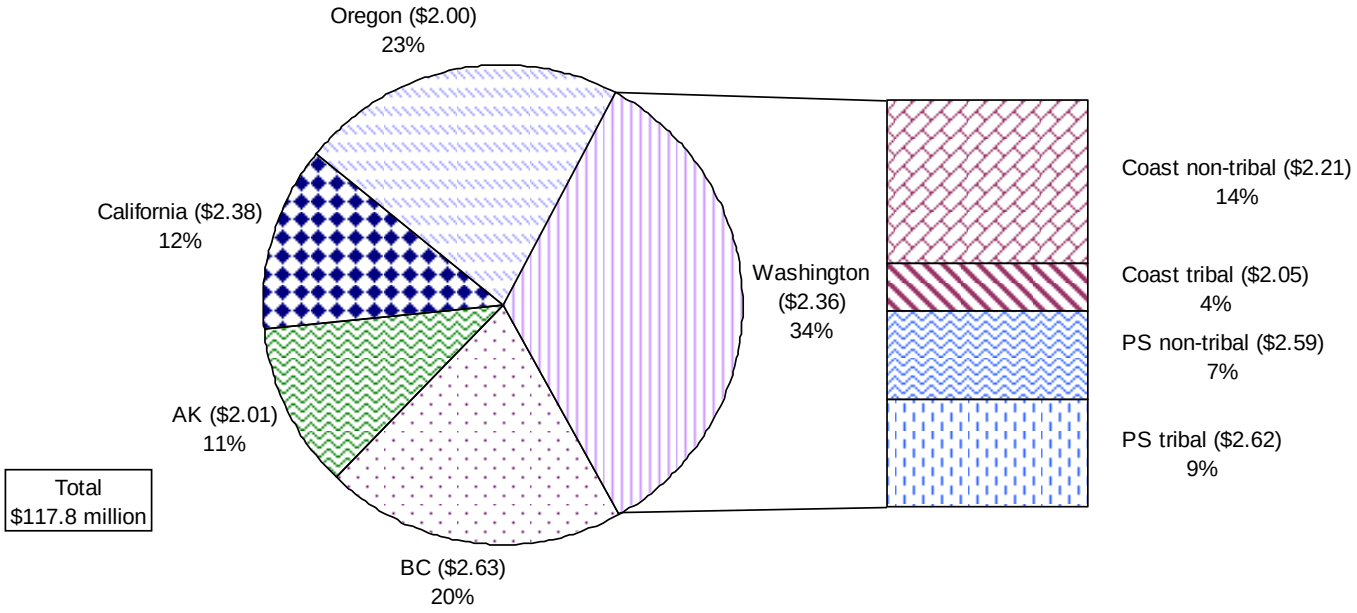
Source: PacFIN annual vessel summary, July 2011 extraction and TRG (2006).

Table 6
Vessel Classification Rules

Order	Vessel Category	Rule Description
1	Mothership/Catcher Processor	Identified by vessel documentation
2	Alaska Fisheries Vessel	Alaska revenue is greater than 50% of that vessel's total revenue
3	Pacific Whiting Onshore and Offshore Trawler	Pacific whiting PacFIN revenue plus U.S. West Coast offshore revenue is greater than 33% of that vessel's total revenue, and total revenue is greater than $100,000
4	Large Groundfish Trawler	groundfish (including sablefish, halibut, and California halibut) revenue from other than fixed gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $100,000
5	Small Groundfish Trawler	groundfish (including sablefish, halibut, and California halibut) revenue from other than fixed gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
6	Sablefish Fixed Gear	sablefish revenue from fixed gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
7	Other Groundfish Fixed Gear	groundfish (including halibut and California halibut), other than sablefish, revenue from fixed gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
8	Pelagic Netter	pelagic species revenue is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
9	Migratory Netter	highly migratory species revenue from gear other than troll or line gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
10	Migratory Liner	highly migratory species revenue from troll or line gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
11	Shrimper	shrimp revenue is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
12	Crabber	crab revenue is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
13	Salmon Troller	salmon revenue from troll gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $5,000
14	Salmon Netter	salmon revenue from gill or purse seine gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $5,000
15	Other Netter	other species revenue from net gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
16	Lobster Vessel	lobster revenue is greater than 33% of that vessel's total revenue, and total revenue is greater than $15,000
17	Diver Vessel	revenue from sea urchins, geoduck, or other species by diver gear is greater than 33% of that vessel's total revenue, and total revenue is greater than $5,000
18	Other > $15 Thousand	all other vessels not above who have total revenue greater than $15,000
19	Other <= $15 Thousand	all other vessels not above who have total revenue less than or equal to $15,000

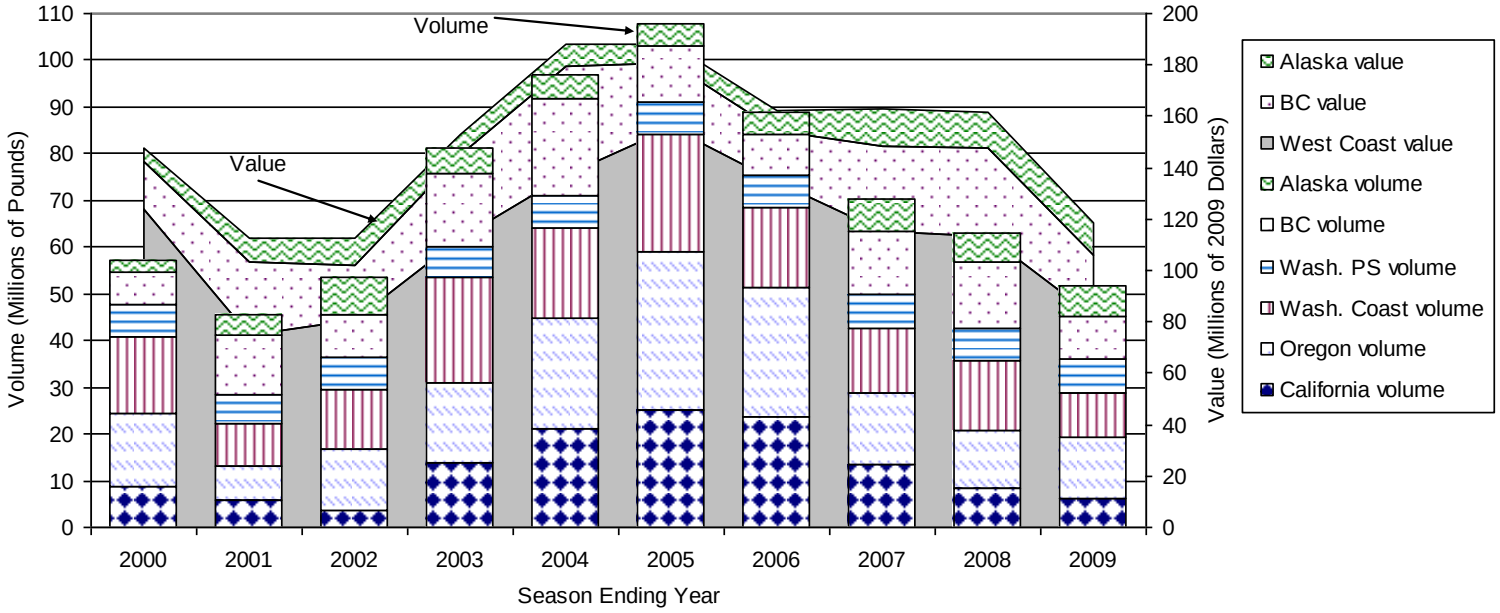
Source: TRG (2006).

Figure 1
Harvest Value Share and Prices for West Coast, Alaska, and British Columbia
Onshore Dungeness Crab Landings in 2008/2009 Season



Notes: 1. Harvest value and prices are in nominal 2009 dollars.
Source: Sylvia and Davis (2011).

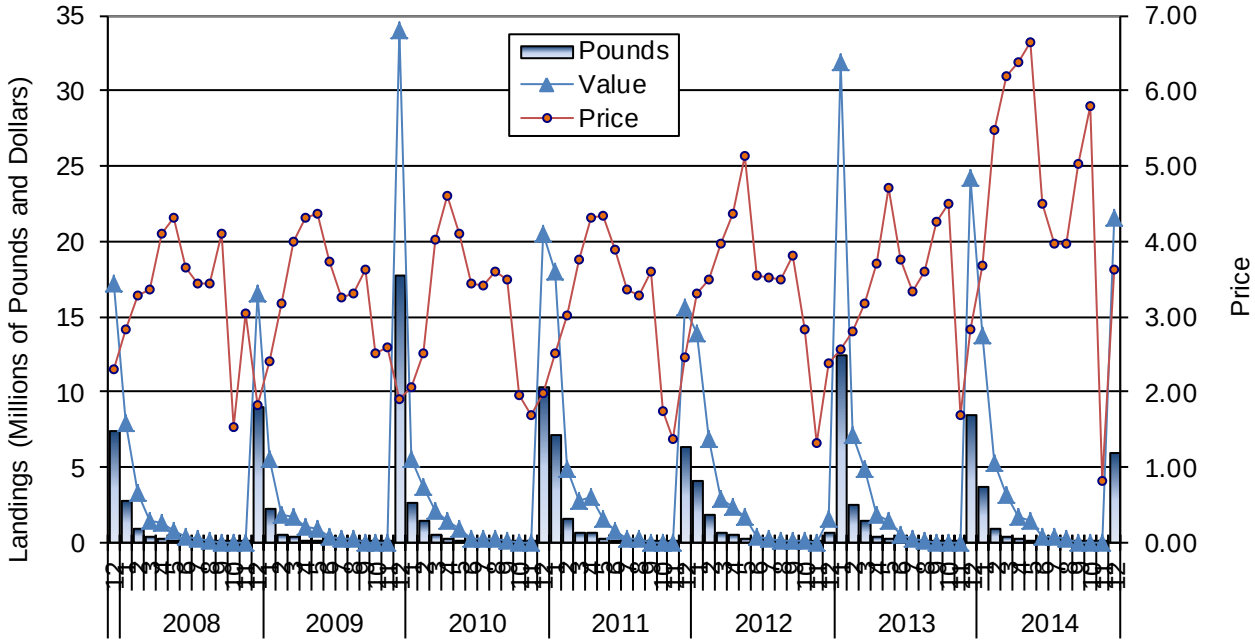
Figure 2
Volume and Harvest Value of West Coast, Alaska, and British Columbia
Onshore Dungeness Crab Landings by Season for the Last 10 Years



Notes:
1. Values are in 2010 dollars adjusted using the GDP implicit price deflator developed by U.S. Bureau of Economic Analysis.
2. Season starts November 15 for California, December 1 for Oregon, December 1 for Washington Coast non-treaty, November 1 for Washington Coast tribal, October 1 for Puget Sound non-treaty, June 1 for Puget Sound tribal, and Alaska and British Columbia are calendar years.
3. Puget Sound includes landings at Puget Sound ports, and Washington Coast includes landings at all other Washington ports. Some Dungeness crab from Puget Sound is landed at Washington coastal ports, and some ocean catch is landed at Puget Sound ports. For example, about eight percent of the landings from Puget Sound catch area are landed at Washington Coast ports rather than Puget Sound ports and about 16 percent of landings at Puget Sound ports are from ocean catch areas during 2006 to 2008.

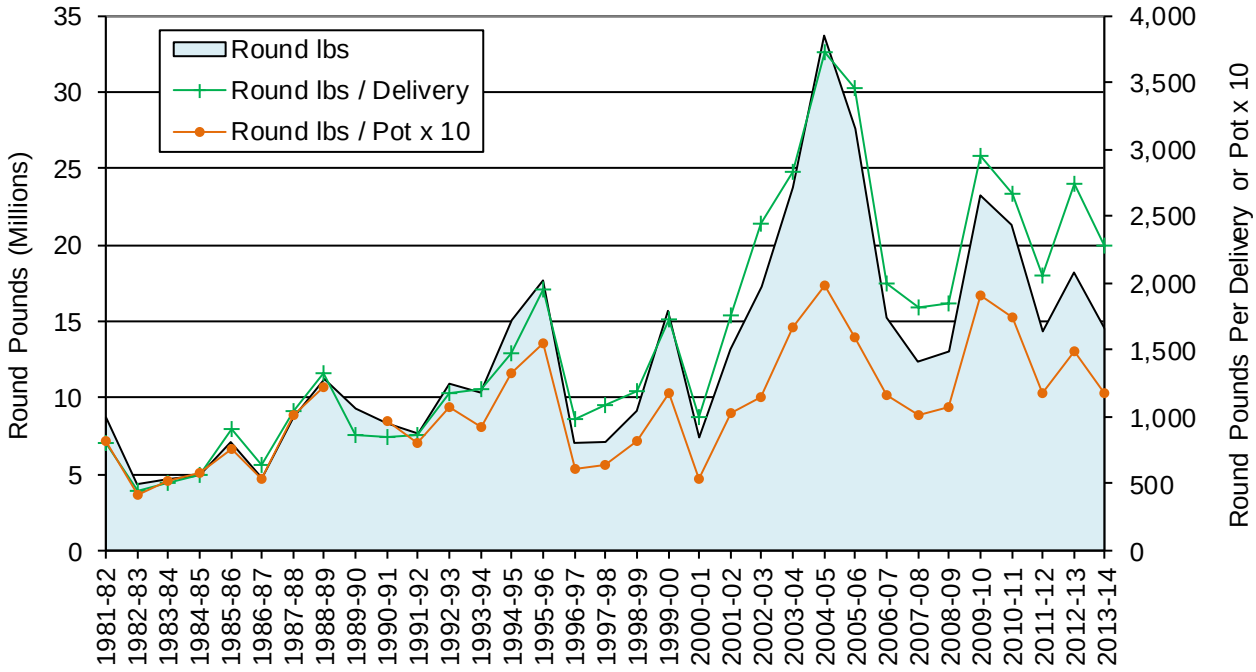
Source: Sylvia and Davis (2011).

Figure 3
Onshore Landed Dungeness Crab by Month in December 2007 to December 2014



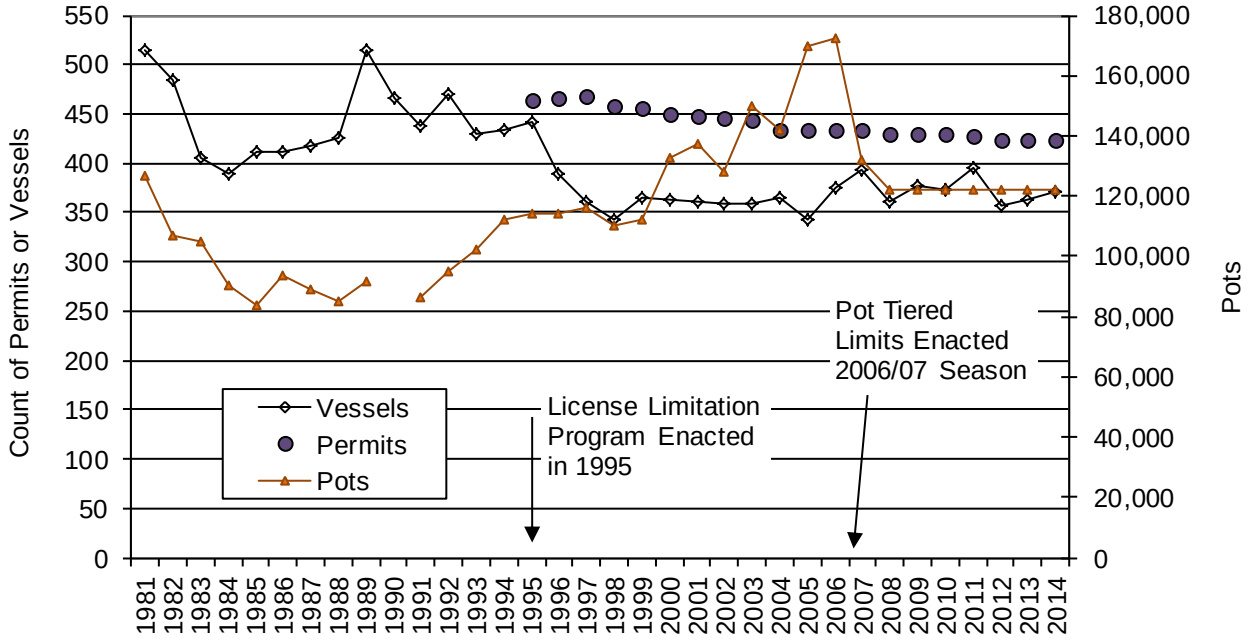
Notes: 1. Values and prices are in 2014 dollars.
Source: TRG (2015).

Figure 4
Dungeness Crab Landings and Effort in 1981 to 2014



Notes: 1. Years are seasonal, from December to November.
2. Notes on Figure 5 concerning pot counts are applicable to this figure.
Source: TRG (2015).

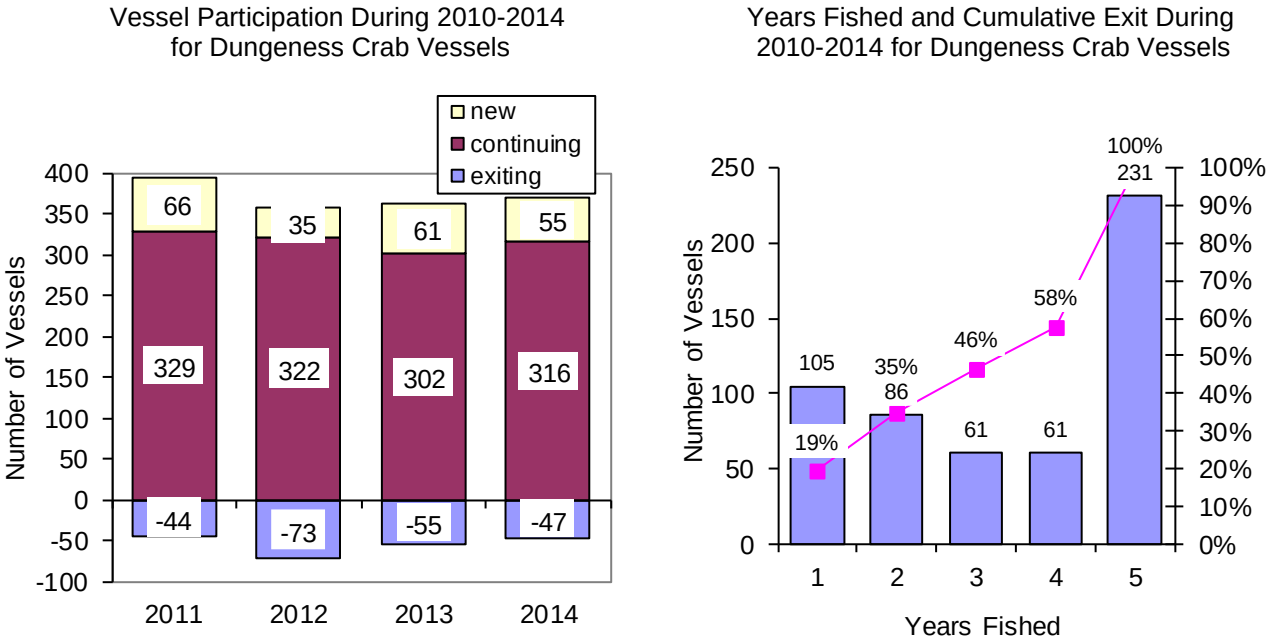
Figure 5
Dungeness Crab Vessel Permits, Active Vessels, and Pots in 1981 to 2014



Notes:
1. Vessels are counted if they make at least one delivery that includes Dungeness crab at an Oregon port. The delivery could be from harvests in a directed Dungeness crab ocean or bay fishery or bycatch, so some vessels do not necessarily hold a limited entry permit. For example, the shown vessel count in 2008 is 361, of which 322 hold ocean limited entry permits. The number of vessels in 2008 holding permits and making at least $500 in landings is 317.
2. Pot counts are from declarations up to year 2006, including vessels that did not make landings, and are from assigned pot tier limits for vessels making landings in Year 2007 and 2008, and repeat 2008 after that. Pot counts are for all vessels permitted from 1995 to 2006, whether or not the vessel participated in the Dungeness crab fishery. The actual number of pots used in harvesting is not tracked.
3. There are pot count issues that might cause undercounts and over counts. The undercounts would occur for vessels that harvest from bays and do not posses an ocean limited entry permit. The over counts would occur if a vessel transferred a permit, causing the permit and associated pot limit to be possessed by more than one vessel during the year.
4. Years are calendar years.

Source: TRG (2015).

Figure 6
Exit and Entry of Vessels in the Dungeness Crab Fishery During the Period 2010 to 2014



Notes: 1. Includes vessels landing any Oregon Dungeness crab during the analysis period.
2. The annual changes include effects from permit transfers from one vessel to another.
Source: TRG (2015).

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